THE Petroleum Engineer

DALLAS, TEXAS OCTOBER, 1933

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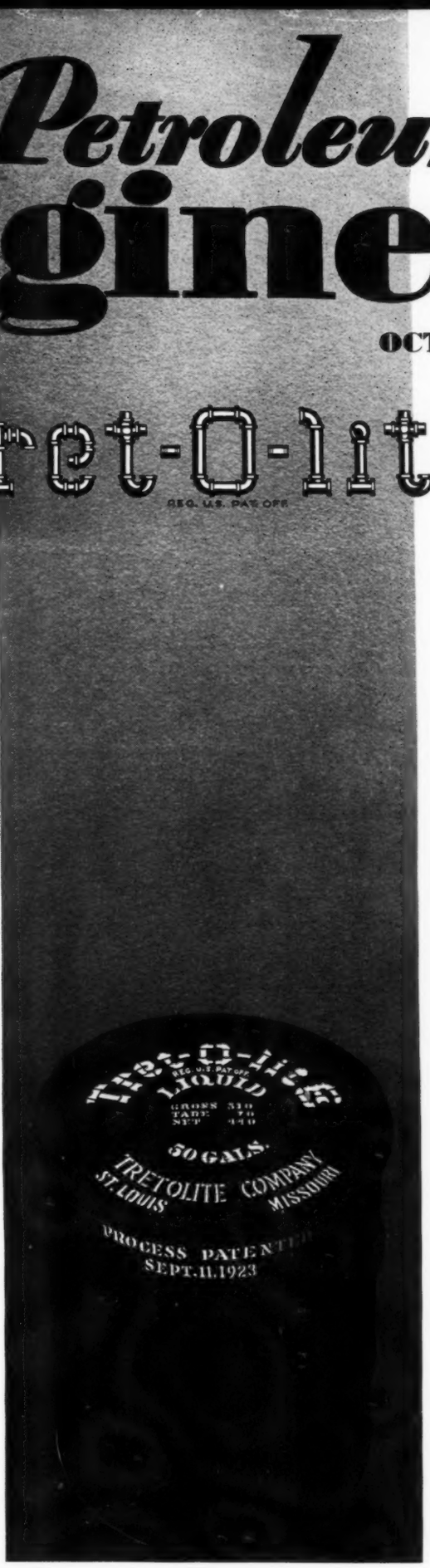

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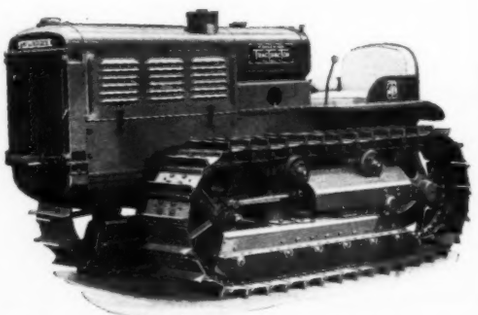

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THE Petroleum Engineer

OCTOBER 1933

VOLUME V NUMBER 1

THE ENGINEERING MAGAZINE OF THE OIL AND GAS INDUSTRY

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Meetings

American Petroleum Institute, Fourteenth Annual Meeting—Stevens Hotel, Chicago, October 24, 25 and 26.

•

American Association of Petroleum Geologists, Pacific Section — Biltmore Hotel, Los Angeles, Calif., November 9 and 10.

•

Rocky Mountain Oil and Gas Association—Great Falls, Montana, December (date not set).

•

American Institute of Chemical Engineers — Roanoke, Va., December 6, 7 and 8.

•

National Automobile Chamber of Commerce — Chicago, January 27 to February 3, 1934.

•

District Chapter Meetings, Department of Production, A.P.I.—

East Texas, Oct. 27.
Wichita Falls, Tex., Oct. 30.
Burbank, Okla., Nov. 8.
Oklahoma City, Okla., Nov. 9.
Wichita, Kan., Nov. 11.
Drumright, Okla., Nov. 13.
Panhandle, Tex., Nov. 14.
San Joaquin Valley, Nov. 21.
Seminole, Okla., Nov. 21.

THE PETROLEUM ENGINEER
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MEMBER A. B. C.

NRA MEMBER U.S. WE DO OUR PART

MEMBER A. B. P.

Two of the four crews that drilled the Gulf Coast deep hole. The drillers were O. C. Wilder, W. L. Harrison, R. Lee Chance and W. A. Carlton

"Hercules" (Red-Strand) Rotary Lines Help Establish Gulf Coast Record

The Yount-Lee Oil Company has drilled the deepest hole ever put down in the Gulf Coast. Their Boyt No. 1 reached a total depth of 9865 feet — and below 7500 feet, heaving shale was encountered. We are proud that "HERCULES" (Red-Strand) Rotary Lines were selected for this big job.

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And neither is the high quality of all Leschen Wire Lines a matter of chance. There are definite factors that account for it; moreover the properties that make it possible for "HERCULES" (Red-Strand) Wire Rope and other Leschen Lines to stand the gaff on these record-breaking holes, also enable them to give safe, dependable and economical service on all oil country work which, at the best, is by no means easy.

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The Course of Oil

By K. C. SCLATER

An Eventful Annual Forum This year the annual meeting of the American Petroleum Institute at Chicago promises to be an especially eventful one. With the petroleum industry still in the throes of the extreme exertion of adapting itself to the many changes that compliance with the code involves, those parts of the proceedings arousing universal interest are the addresses of Mr. Ickes, Secretary of the Interior and Oil Administrator, and two prominent members of important committees aiding in administering the code, Wirt Franklin and C. E. Arnott. Wirt Franklin is chairman of the Planning and Coordination Committee, and C. E. Arnott, chairman of the Marketing Committee of the Planning and Coordination Committee. What they have to say is expected to disclose an intimate picture of the problems and obstacles besetting the efforts of the oil industry in putting the code into effect. Conflicting angles of the code over which storms of controversial opinion have raged it is hoped will be clarified sufficiently to dispel the confusion that now exists and pave the way to further progress.

Mr. Ickes' acceptance of an invitation to be present at the meeting may be taken as evidence of his concern in seeing that the oil industry is given every opportunity to conduct its operations on a sound basis while living up to the provisions of the code. In the present circumstances, therefore, his attendance at the meeting is most opportune and has a touch of significance.

No gathering during the year has the widespread appeal to the interests of oil men that this meeting enjoys. It is now an event and has come to occupy this prominent place in the oil calendar principally because of the vital character of the discussions, and the deliberations resulting therefrom, that take place. These affect the general welfare of the petroleum industry in all its ramifications. Here leaders in every branch of the business foregather to grapple with their common problems.

In the Divisions of Production and Refining an excellent program has been prepared. Many papers will be presented bearing on every important phase of the production and refining practice. The contents of most of these papers represents the results and findings of months of incessant labor in the field, the office, the laboratory and the workshop. It is on such contributions as these that the progress of the oil industry is based. The discussions that follow the reading of the papers are a valuable feature of the sessions. This interchange of opinion is a stimulus to thought and action leading to further improvements in practices and technique.

Altogether the Institute meeting this year affords the industry an opportunity to take stock of what has thus far been accomplished under the code and should aid it in overcoming difficulties during the months to come.

Gas-Oil Ratio and Proration Recently the Corporation Commission of Oklahoma put into effect a new regulation for the proration of wells in the Oklahoma City field. Wells producing with a gas-oil ratio of not more than 5000 cubic feet per barrel are classed as normal wells and permitted to produce their full normal daily production allowable. Wells with a gas-oil ratio greater than 5000 cubic feet and up to 20,000 cubic feet per barrel are penalized because of a high gas-oil ratio. They are permitted to produce only part of the normal daily allowable they would be allowed with a gas-oil ratio of 5000 cubic feet or less. This part is the fraction determined by the upper gas-oil ratio of a normal well divided by the gas-oil ratio of the well. Thus if a well has a gas-oil ratio of 15,000 cubic feet per barrel it would be allowed only one-third of its normal production. In adopting this regulation the purpose is to conserve the gas energy in the sand and reduce the subsequent lifting cost at wells. The cost of lifting oil in this field by methods other than natural flow is high. It has been received by operators as a constructive conservation measure that will be flexible enough to insure equity to all operators and one that will work to their subsequent benefit. Whatever the wisdom and justice of the regulation, it is propitious evidence of the tendency to get away from arbitrary methods of proration that have no basis of application so far as reservoir conditions are concerned.

Encouraging an Essential Activity Wildcat drilling shall not be prohibited. So states a recent amendment to the NRA code on prospecting operations. Although wildcatting is permitted, new fields are required to be developed in accordance with a plan approved by the President

For some time past it has been evident that fear that wildcatting would be prohibited or seriously curtailed under the code caused many operators to limit the scope of their operations in this essential prospecting activity. This is a definite and encouraging announcement that removes the baneful reaction resulting from uncertainty. Its beneficial effects are already evident; leasing and prospect-drilling activities have increased. Several major companies are now laying plans for intensive prospecting campaigns. While there has been a certain amount of prospecting going on during the last three years, on the whole it must be said that systematic prospecting has been far short of what experience dictates it should have been. New sources of supply cannot be tapped at will. The discovery of new fields is still largely a hit-or-miss undertaking even under the most intelligent and experienced guidance. Quite aside from the expense of prospecting to discover a field or pool there is, so far as it concerns the industry as a whole, that important element—time.

« « « HIGHLIGHTS IN OILDOM » » »

National Allowable Output Lowered The oil production allocation, effective at 7 A. M., October 8, as announced by Secretary Ickes, was 2,337,500 bbl. a day, compared with the previous total of 2,409,700 barrels. A feature of the new order, which may remain in effect until the first of the year, is the granting of permission to states to allocate part of their allowable to withdrawals from storage.

The allocations by states follow: Arkansas, 33,000; California, 455,000; Kansas, 116,000; Louisiana, 70,000; Texas, 965,000; Oklahoma, 495,000; New Mexico, 41,400; Rocky Mountain States, 38,900; Appalachian States, 94,200; and Michigan, 30,000 barrels.

●

Another Rise in Crude Price Led by The Texas Company, Mid-Continent purchasers of crude oil advanced the price in Oklahoma, North Texas, Central Texas, East Texas, Arkansas and North Louisiana an average of 11 cents per bbl. on September 29. Later the increase spread to the Gulf Coast, Southwest Texas, West Texas, Montana, Wyoming, Colorado, New Mexico, Ohio, Indiana, Illinois, Michigan and Kentucky.

East Texas oil for the first time in years is selling for $1.00 per barrel. The top price for 40 gravity in Oklahoma and Kansas is now $1.08.

●

Federal Control Brings Drop in Output There occurred during September a sharp drop in the Nation's output of crude oil, despite the fact that federal allocation of production did not go into effect until the eighth of the month and that it was almost a week later before any material reduction was made in the daily output. The daily average production during September was 2,557,300 bbl., as compared with 2,758,500 bbl. during the month of August. At the close of September (for the week ending September 30) the output of the United States was down to 2,446,850 bbl., which compares favorably with the allowable of 2,409,700 bbl., set by the Federal government. The first week in October showed a further decrease in domestic production when an average of 2,398,850 bbl. was produced daily. The result has been a higher price for crude oil and refined products and a general healthier situation.

●

Drilling Work Increases Drilling activity in the United States for the third consecutive month showed an increase during the month of September. A total of 999 completions were made as compared with 854 during the preceding month. Drilling wells at the close of the month totaled 2321 as compared with 2053 operations the previous month. The number of rigs on September 30 was also higher by 132 than at the same period in August. The sharp increase in field activity reflects the confidence felt by oil industry leaders in stabilization efforts of the United States and improvements in the crude price market.

●

Ouster Suit Thrown Out of Court The $17,850,000 ouster suit by Attorney General Allred of Texas against 15 oil companies and two trade associations has been thrown out of court by a Texas District Court judge on the grounds that the National Industrial Recovery Act has an influence on the anti-trust statutes of Texas. Attorney General Allred sought to cancel charters and permits to do business as well as collect the huge penalty sum on the grounds that the anti-trust laws of Texas had been violated when provisions of the National Code of Practices for the selling of Refined Petroleum Products were applied in Texas. The code was brought into existence by the American Petroleum Institute through the Federal Trade Commission several years ago.

●

NRA Wins Injunction Suit Efforts of East Texas refining concerns to prevent federal investigators from taking information from their oil receipts and shipments were unsuccessful when a plea for an injunction was denied in Federal court. The suit was based on the contention that regulations of the petroleum code, granted under the National Industrial Recovery Act, were unconstitutional.

●

Government Fixes Crude Price Secretary Ickes, the oil administrator, on October 16 issued an order fixing minimum prices for petroleum and its products effective as of December 1. The base level for 36 gravity Mid-Continent crude was set as $1.11 a barrel, while prices for other classes ranged up and down according to their quality. The price for 60-64 octane gasoline in the Mid-Continent was set at 6½ cents a gallon, while for the Eastern Seaboard it was placed at 7¼ cents. The Pacific Coast was allowed 7¾ cents a gallon for tank car prices.

●

Strong Hand To Enforce Oil Code Harold L. Ickes, Secretary of the Interior and administrator of the oil code, has instructed his chief investigator, Louis Glavis, to proceed with investigation of cases of violation under the oil code. He has also appealed to the public not to patronize under-selling filling stations.

It is understood that a large corps of investigators will be put in the field by the administrator. Already, these investigators have made appearances at Dallas, Texas, and Brooklyn, N. Y., where below-cost selling has been prevalent.

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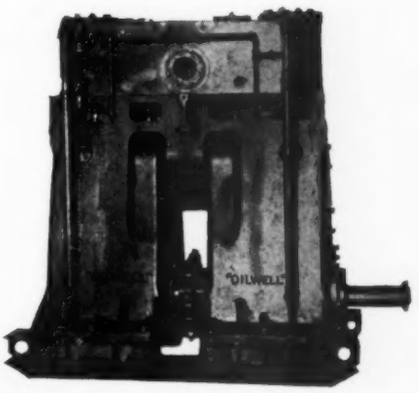

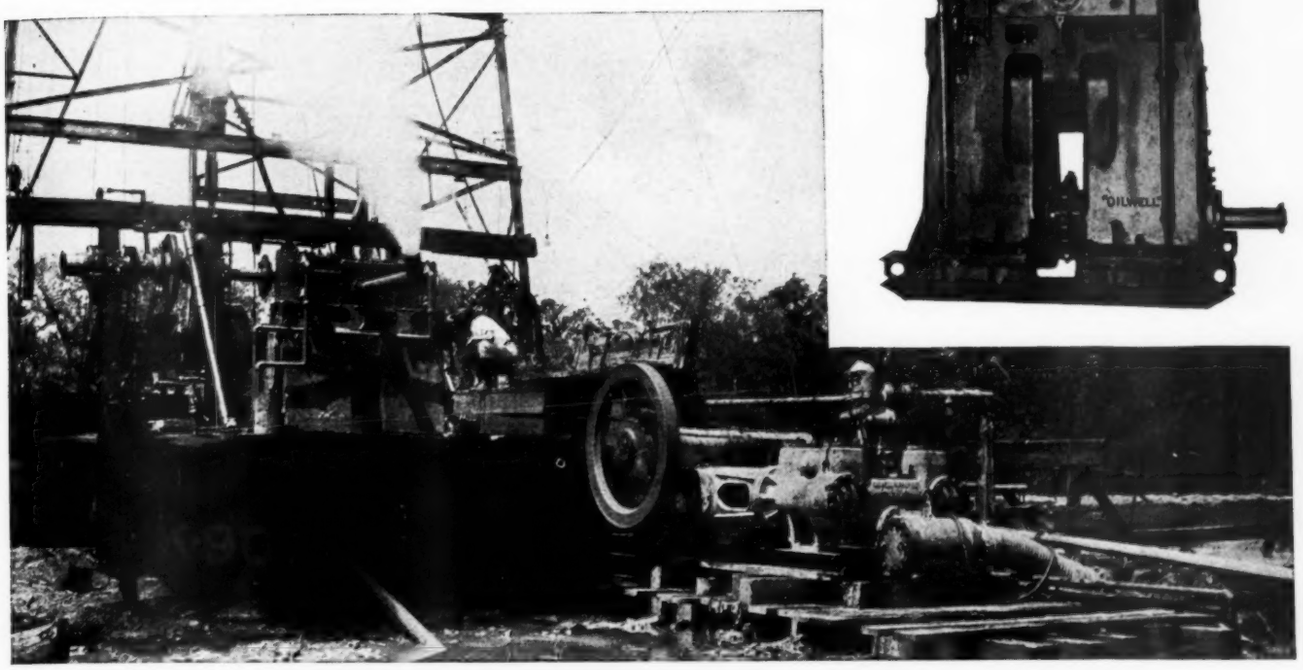

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★ **Hand-controlled variable steam cut-off** uses steam expansively. Cut-off adjustable for light and heavy loads greatly reducing steam consumption.

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"OILWELL"

LATEST ACTIVITIES IN THE OIL FIELDS

ARRIOLA salt dome, Hardin County, southeastern Texas, gives promise of developing into an important new oil field for the Gulf Coast as a result of the spectacular performance of its third producer. The well, Republic Production Company and Houston Oil Company's Fee 4, has been killed after having been out of control for three days. It is estimated to have flowed 8000 bbl. and 30,000,000 cu. ft. of gas during the last day. Total depth of the well is 4227 feet.

•

The second field for Polk County, Texas Gulf Coast, was opened when the rank wildcat of Dick Schwab tested dry gas from 4748 to 4771 feet. This well is located about seven miles east of the Livingston field, which was discovered last year by Schwab. No gauges have been made on the well, but estimates range as high as 40,000,000 cu. feet. It registered 600 lb. pressure on a drill stem flow.

•

Attention of the oil fraternity was centered upon the Palestine area of Anderson County, eastern Texas, where the Texas Seaboard Oil Company and Tide Water Oil Company encountered a flow of 60,000,000 cu. ft. of gas from the Woodbine sand in a rank wildcat test. The well was drilled deeper to 5468 ft., but is now plugged back to test the gas horizon. It is located on a 25,000-acre block.

•

A new producing horizon has been opened in the Greta district of Refugio County, Southwestern Texas Coastal area, which also extends the field a mile and a half east. The new well has sand at 5911-18 ft., where it is flowed 1200 bbl., on a half-inch choke. This discovery is probably the most important development since the bringing in of the field several months ago. It places a large area in the play and also indicates that Greta may be similar to the Refugio field, which has a number of producing horizons.

•

Indications are that if state officials will permit drilling within the city, production may be found three miles north of the present producing limits of the Oklahoma City field, judging by the test well of Frank Russell, Inc. Although little information has been made available by the owners, estimates of the well's producing ability have varied from a few hundred to 3000 bbl. per day.

•

Swabbing at the rate of 400 bbl. daily, Montana Headlight Company's test in Section 14-34-6w, gives indications of being the largest well in the Cut Bank, Montana, field. The test encountered the Darling sand at 2863-90 feet.

•

The new Crescent pool in Logan County, central Oklahoma, apparently has received its first setback. A test well now drilling, although already several hundred feet beneath the level at which a production of 5700 bbl. was found in the discovery well, fails to show anything. This test is more than one-half mile northeast of the discovery producer.

AVERAGE CRUDE OIL PRICES

California		Arkansas	$ .70
Playa Del Rey	$ .90	Louisiana	
Coalinga	.81	North Louisiana	.95
Long Beach	1.00	Gulf Coast	1.04
Signal Hill	1.12	Illinois	1.22
Montana	1.10	Kentucky	1.17
Wyoming	1.00	Indiana	1.15
Colorado	1.00	Ohio	
New Mexico	.75	Lima	1.30
Texas		Wooster	1.15
North Central	.95	Michigan	1.02
Panhandle	.83	Pennsylvania	
West Texas	.70	Bradford	2.45
Gulf Coast	1.04	Southwest	2.12
Darst Creek	.87	Corning	1.20
East Texas	1.00	West Virginia	2.07
Kansas	1.00	Canada	2.10
Oklahoma	1.00		

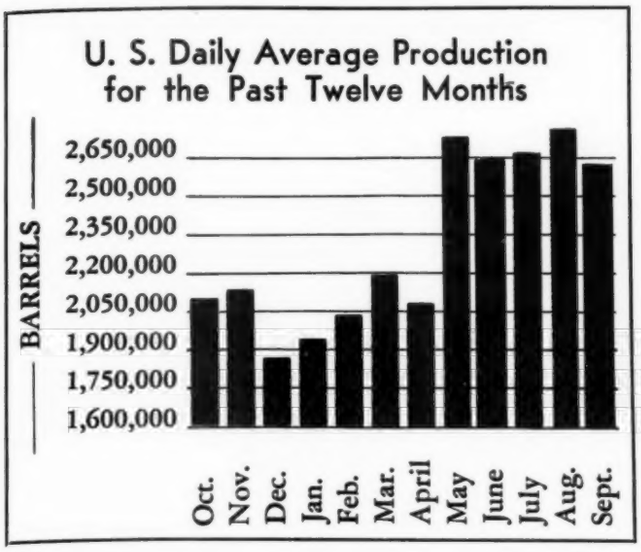
DAILY AVERAGE CRUDE OIL PRODUCTION

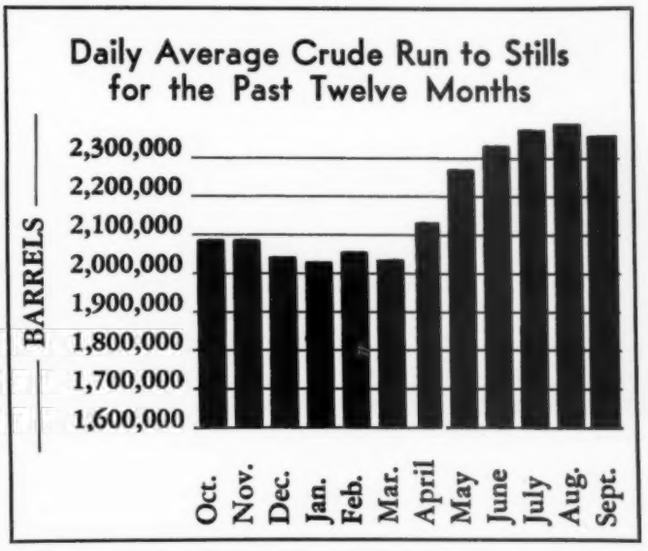
(Figures in Barrels)

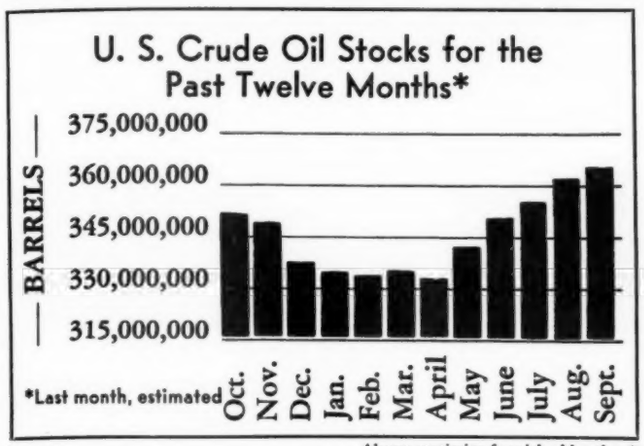
Furnished by A.P.I.

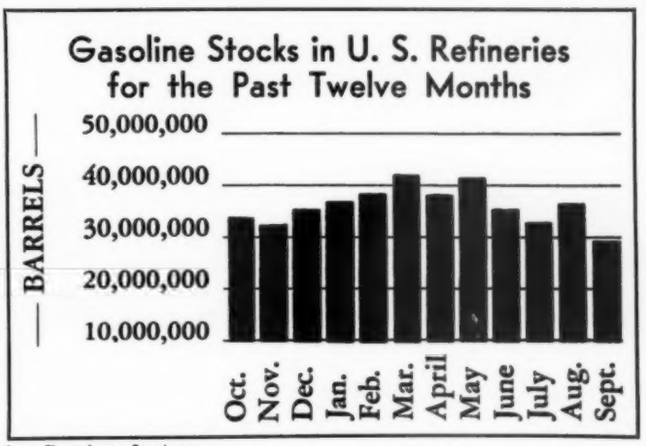
	Week Ended Sept. 30, 1933	Week Ended Aug. 26, 1933	Week Ended Oct. 1, 1932
Oklahoma	527,650	605,500	386,550
Kansas	121,650	128,950	100,150
Panhandle Texas	45,600	47,600	44,000
North Texas	53,100	53,050	49,450
West Central Texas	21,800	21,900	24,200
West Texas	127,700	161,200	170,350
East Central Texas	46,300	58,550	52,050
East Texas	476,600	605,950	379,200
Conroe	73,400	86,800	14,200
Southwest Texas	46,750	51,950	54,450
Coastal Texas (Not including Conroe)	112,100	129,250	127,500
Total Texas	1,003,350	1,216,250	915,400
North Louisiana	25,800	26,150	30,100
Coastal Louisiana	47,850	46,850	33,600
Total Louisiana	73,650	73,000	63,700
Arkansas	32,450	31,300	34,400
Eastern (Not including Mich.)	99,600	92,500	98,250
Michigan	30,000	28,400	23,650
Wyoming	30,950	28,850	30,900
Montana	6,600	6,450	7,600
Colorado	2,350	2,400	2,950
New Mexico	42,000	41,400	31,450
California	476,000	501,400	477,000
TOTAL	2,446,850	2,756,400	2,172,000

[1]Production figures furnished by the American Petroleum Institute.









Above statistics furnished by the American Petroleum Institute

Summarized Operations in Active Fields for September, 1933

Fields	Completions	Producers	Locations	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
TEXAS									
East Texas	256	262	274	65	168	3600	2	40	Rotary
Duval County	22	18	16	9	25	2300	2	22	Rotary
Conroe	48	41	43	21	35	5200	2	38	Rotary
OKLAHOMA									
Oklahoma City	3	2	5	20	28	6500	3	39	Rotary
KANSAS									
McPherson County	9	6	9	7	34	2900-4300	2	38	Rot.-Cab.
Ellsworth Arch	15	11	14	6	29	3300	4	37	Cable
Harvey County	18	10	5	10	30	3450	2 or 4	37	Rot.-Cab.
CALIFORNIA									
Kettleman Hills	3	3	3	1	13	8300	3 or 4	40	Rotary
Long Beach	11	11	5	6	22	7000	3	26	Rotary

Field Activities by States for September, 1933

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1932 (In Barrels)
	September	August	September	August	September	August	September	August	September	August	
Arkansas	0	7	0	0	3	2	7	7	29	32	11,907,000
California	27	20	27	17	116	179	57	39	134	130	178,128,000
Colorado	3	4	0	1	....	....	5	4	50	58	1,177,000
Illinois	3	1	1	1	....	....	1	1	13	13	4,661,000
Indiana	0	14	0	11	....	....	1	4	29	25	804,000
Kansas	67	33	45	27	60	80	41	30	124	101	34,300,000
Kentucky	18	1	9	7	....	....	2	3	54	51	6,264,000
Louisiana	42	45	19	19	49	106	47	39	137	140	21,478,000
Michigan	32	26	23	19	58	76	98	65	115	83	6,729,000
Mississippi	2	5	2	4	....	....	8	3	15	15	Gas Prod.
Montana	10	10	8	3	....	....	4	7	41	48	2,449,000
New Mexico	6	5	1	2	....	....	7	10	52	45	12,511,000
New York	9	0	9	0	....	....	2	4	19	21	3,501,000
Ohio	70	55	55	34	....	....	40	33	133	129	4,597,000
Oklahoma	85	96	50	60	111	104	81	98	300	253	152,621,000
Pennsylvania	100	16	25	12	....	....	21	13	116	87	12,403,000
Texas	503	475	467	334	881	1174	219	149	837	701	311,069,000
West Virginia	19	26	14	22	....	....	25	23	56	52	4,472,000
Wyoming	3	5	3	4	....	....	9	11	67	70	12,359,000
TOTAL	999	854	748	558	1278	1730	675	543	2321	2053	781,845,000

PROGRESS OF MAJOR PIPE LINE WORK

By WARREN L. BAKER

THE first increase registered in sales of manufactured and natural gas since April, 1930, occurred during August, when sales aggregated 77,396,700,000 cu. ft., an increase of 4.4 per cent over the corresponding month of the preceding year. The sales increase resulted largely from increased consumption of gas for industrial purposes. This was true particularly in the case of natural gas. During August, sales of natural gas totaled 51,839,500,000 cu. ft., an increase of nearly 7 per cent.

Much new work in the way of natural gas pipe line construction is presaged by the trend of industrial plants toward the use of natural gas as fuel. At this time a large number of industrial plants in the north central and eastern states are being connected with natural gas supply by trunk lines laid from the Mid-Continent and Eastern fields during the past three years. This practice, it is thought, will become more general in coming months. Most of the pipe line work will consist of the building of short laterals from the already existing main lines.

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Construction is now well under way on the Western Gas Company's 216-mile 10-in. gas line from Douglas to Phoenix, Arizona. This is the longest gas line project laid thus far this year. Bechtel Kaiser Co., Ltd., and Henry J. Kaiser Co., of San Francisco, Calif., are the general contractors. H. C. Price, Inc., of Bartlesville, Okla., has received the electric welding contract for the line.

•

Pan-American Pipe Line Company, a newly organized branch of the Standard Oil Company of Indiana, has taken over the operation of the Stanolind Pipe Line Company's Gulf Coast system, which is located south of Dawes Station, on the Houston ship channel. The system to be operated by Pan-American includes 17 miles of 10-in. and 31 miles of 12-in. from Sinco to Texas City, where the Pan-American Refining Company is erecting a refinery. Stanolind will continue to operate the trunk system from north and east Texas to Dawes Station. The Baytown line of the Pan-American is a part of the new 42-mile line that Stanolind has recently completed from Hufsmith Station to Dawes Station.

•

Construction work on the Minnesota Northern Natural Gas Company's 18-in. line from Owatoona, Minn., to St. Paul is expected to be completed shortly. Work is now finished to a point between Faribault and Rosemount and 18-in. pipe has been strung to Rosemount and 12-in. pipe from Rosemount to the Armour and Swift packing companies in South St. Paul. Fredell Construction Company of Denver, Colo., is the general contractor and H. C. Price, Inc., Bartlesville, Okla., the welding contractor.

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Lycoming Production Corporation, a subsidiary of the Standard Oil Company of New Jersey, is planning to build a 40-mile pipe line from the Potter County gas fields, near Wellsboro, Pa., to its own 20-in. line running to Syracuse, New York.

•

Inland Pipe Line Company has been granted a permit to construct a natural gas pipe line from the Burrton gas field in western Harvey County, Kansas, to Emporia, Kansas. Except for the sale of a small amount to the Cities Service Gas Company, this field with an open flow of more than 300,000,000 cu. ft. daily has been almost bottled up since its discovery two and one-half years ago. Several towns along the route from Burrton to Emporia may be served from the Inland line.

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The laying of an 8-in. natural gas pipe line from Sylvania, Potter County, Pa., to Betula, McKean County, has been completed by the Sylvania Corporation, a subsidiary of the United Natural Gas Company. The line is approximately 30 miles in length.

•

B. G. Herring, representing the Independent Utilities Company, which is seeking the natural gas franchise in cities along the route of a proposed gas line from Jackson field in Mississippi to Mussel Shoals, Ala., states that more than 30 cities have agreed to become subscribers. The company has made an offer to furnish gas to consumers at a minimum of $1.20 for the first 2000 cu. ft. and 60 cents for each additional thousand up to 7000 ft., after which the rate would drop to 45 cents.

•

As yet the Federal government has taken no action on the application for a federal loan of $575,000 made several months ago by George E. Brimmer and associates for an oil pipe line from the Maverick Springs field in Fremont County, Wyoming, to Riverton, Wyo., a distance of about 40 miles. The field was discovered in 1921 but no oil has been marketed from it. Estimated potential production of the pool is 10,000 bbl. per day.

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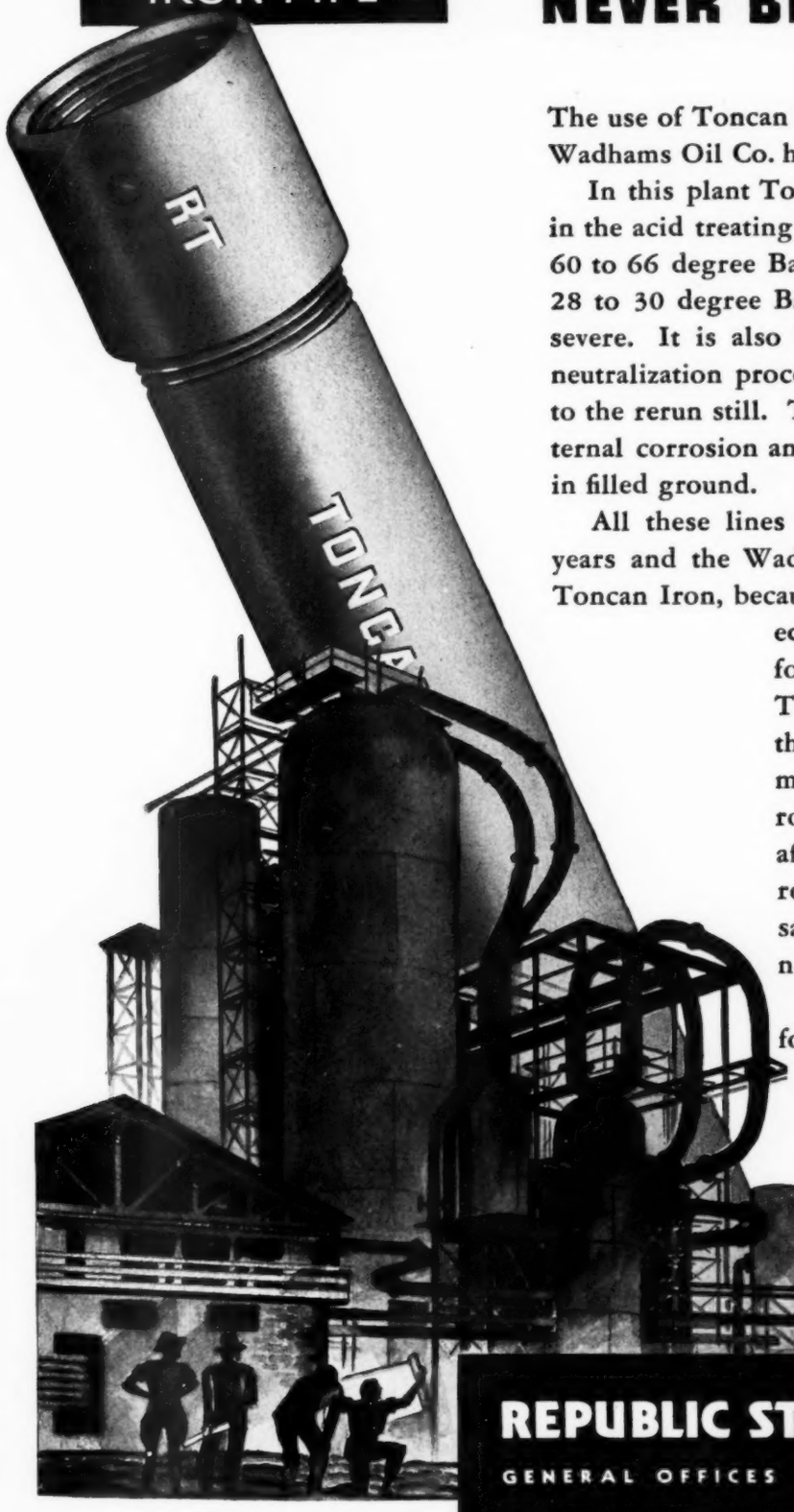


The use of Toncan Iron Pipe in the Chicago refinery of Wadhams Oil Co. has uncovered some interesting facts.

In this plant Toncan Iron Pipe has been in service in the acid treating department for four years handling 60 to 66 degree Baume sulphuric acid and acid sludge 28 to 30 degree Baume. These two services are quite severe. It is also being used for caustic lines in the neutralization process and in the treated distillate line to the rerun still. This distillate line is subjected to internal corrosion and external corrosion since it is laid in filled ground.

All these lines have been in service three to four years and the Wadhams Oil Co. is enthusiastic about Toncan Iron, because this performance has never been equalled by any other pipe used before. Yet it only bears out what other Toncan Iron users have learned—that this alloy of refined iron, copper and molybdenum ranks first among the ferrous metals in resistance to corrosion, after the stainless steels. Its use in your refinery or your wells, where acid or salt conditions play havoc with ordinary pipe, will prove a real economy.

Write today for a copy of "Pipe for Permanence."

REPUBLIC STEEL CORPORATION

GENERAL OFFICES YOUNGSTOWN, OHIO

THE MONTH'S ACTIVITIES IN REFINING

By F. R. STALEY

Per Cent Refining Capacity Operated

Eastern Division 74.4 Per Cent **Central Division 67.2 Per Cent** **Western Division 53.4 Per Cent**

EXPORT and domestic coast-wise buying of gasoline, which assumed enormous proportions in the Mid-Continent and the Gulf Coastal areas, were highlights of oil markets during recent weeks. Europe, owing to an acute shortage in Soviet Russia and Rumanian supplies, has taken large quantities of gasoline and kerosene from the Gulf market. A single export order for 70,000 bbl. of 64-66, 375 end point gasoline was placed in East Texas. Orders for a total approximating 140,000 bbl. of 400 end point gasoline also were placed in the Mid-Continent for shipment to the Eastern coast via the Gulf. Russia's inability to supply the markets it formerly flooded with oil stimulated demand for Rumanian oil until that industry is completely sold out for the time being. With the continued decrease of the Russian supply, Europeans have been driven in increasing numbers to look to the United States for their supplies. This condition is particularly beneficial at this time to domestic exporters as they are faced with the loss of the French market in the near future. The French refinery construction program is nearing completion, which means that the French demand of approximately 20,000,000 bbl. of motor fuel yearly will be supplied by French plants. Already some of the plants are in operation. As the French inquiry for finished products declines a marked increase has been noted in the demand for American crude for cracking purposes. Until the Iraq Petroleum Company's pipe line from Iraq to terminals on the Mediterranean sea are completed American crude oils will be demanded by the French refineries.

●

Natural gasoline plant construction work in the East Texas field has assumed more importance. Several plants are definitely scheduled to be built, others are under construction and rumors are that additional plants will shortly be announced. The Gregg-Tex Gasoline Corporation, Shreveport, La., has its new natural gasoline plant in Gregg County practically completed and is expected to commence operation this week. This plant, with a capacity of 10,000,000 cu. ft. of gas daily, is one of the largest in the East Texas field. The equipment includes six twin-type Clark engines. The Hercules Gasoline Corporation, Shreveport, La., is erecting a casinghead gasoline plant near the refinery of the Kilgore Refining Company that will have a daily capacity of 3,500,000 cu. ft. of gas. It will be a compression plant, equipped with four 165-hp. Cooper-Bessemer engines. Construction of two more natural gas plants in the East Texas field has been announced by the Tall Pines Natural Gasoline Corporation. One plant will be constructed near London, Texas, and the other in the north end of the field.

●

Consolidated Petroleum Distributors Company, San Francisco, Calif., plans the construction of a refinery on Rough and Ready Island, Stockton, Calif. Estimated cost is $1,500,000.

●

Construction of two new independent refineries in the Mount Pleasant area of central Michigan is planned. The Midwest Oil Company will erect a 1000-bbl. skimming plant at Alma. B. J. Skinner of Grand Rapids, formerly associated with the Wolverine Oil Company, is head of the company. E. G. Guy, former superintendent for the Old Dutch Refining Company at its Muskegon plant and of the Roosevelt refinery at Mount Pleasant, is back of a project at St. Louis, details of which are not yet available.

●

The Big West Oil Company of Montana has signed a license contract with Universal Oil Products Company and has started construction of a Dubbs cracking unit. Big West owns a refinery at Kevin, Montana, which, when remodeled, will have a crude processing capacity of 1000 bbl. daily. The old shell stills are being replaced with a modern tubular furnace; a Dubbs gasoline reforming unit and a Dubbs cracking unit are being installed. Ralph M. Parsons, consulting and contracting engineer, of Mount Vernon, Ohio, is doing the erection work.

●

Pennsylvania Refining Company of Butler, Pa., plans the construction of a new unit, as well as improvements at its refinery at Titusville, Pa. Arthur G. McKee Company of Cleveland, Ohio, will do the construction work. Estimated cost is $125,000.

●

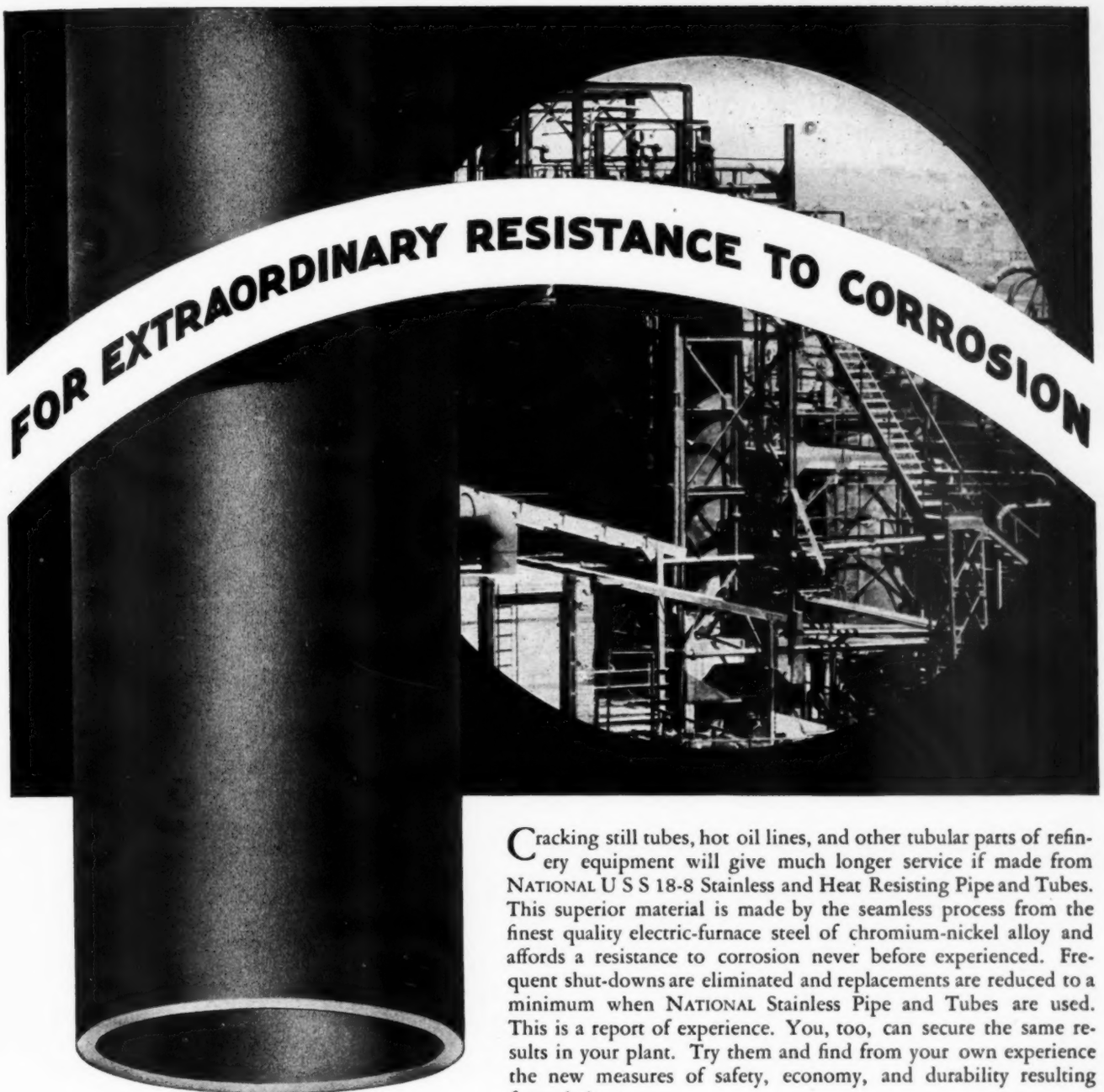
Mississippi's first oil refinery, the Dixie Oil and Refining Company's 1500-bbl. plant at Jackson, made its first commercial run of crude late in September. It is operating on crude shipped by tank cars from East Texas. The owners are understood to be contemplating the installation of a cracking still.

Crude Runs to Stills, Gasoline and Gas and Fuel Oil Stocks, Week Ending September 30, 1933

A.P.I. Figures

(Figures in Barrels of 42 Gallons Each)

DISTRICT	Per Cent Potential Capacity Reporting	Daily Avg. Crude Runs to Stills	Per Cent Operated of Total Capacity Reporting	Total Motor Fuel Stocks Thousands of Bbl.	Gas and Fuel Oil Stocks Thousands of Bbl.
East Coast	100.0	477,000	82.0	13,541	9,209
Appalachian	92.6	89,000	63.7	1,894	842
Ind., Ill., Ky.	97.3	330,000	77.6	6,593	5,774
Okla., Kans., Mo.	82.1	266,000	70.1	5,215	4,354
Inland Texas	58.7	88,000	54.6	1,325	1,813
Texas Gulf	98.0	447,000	89.8	5,545	7,039
Louisiana Gulf	100.0	93,000	57.4	1,262	1,860
No. La.-Ark.	92.6	49,000	64.1	225	663
Rocky Mountain	78.8	34,000	53.5	805	723
California	96.9	439,000	53.4	14,052	99,289
Total Sept. 30, 1933	92.2	2,312,000	69.9	50,457	131,566
Total Sept. 23, 1933	92.2	2,339,000	70.7	49,944	130,951



Cracking still tubes, hot oil lines, and other tubular parts of refinery equipment will give much longer service if made from NATIONAL U S S 18-8 Stainless and Heat Resisting Pipe and Tubes. This superior material is made by the seamless process from the finest quality electric-furnace steel of chromium-nickel alloy and affords a resistance to corrosion never before experienced. Frequent shut-downs are eliminated and replacements are reduced to a minimum when NATIONAL Stainless Pipe and Tubes are used. This is a report of experience. You, too, can secure the same results in your plant. Try them and find from your own experience the new measures of safety, economy, and durability resulting from their use.

Available in a wide range of diameters, wall-thicknesses, and lengths. Can be easily bent, welded, or otherwise fabricated. Produced with unrivaled facilities, by the largest manufacturers of tubular products in the world, offering a complete piping service to the refining industry. NATIONAL engineers and metallurgists will be glad to aid in determining the best application to any particular requirement. Descriptive literature on request.

ADVANTAGES

Seamless—No welds.
High resistance to corrosion.
Maximum strength at high temperatures.
Unusual resistance to oxidation or scaling.
Dependable uniformity of structure.
Accurately controlled heat treatment.
Sentry Drilled (when ordered) an exclusive feature.

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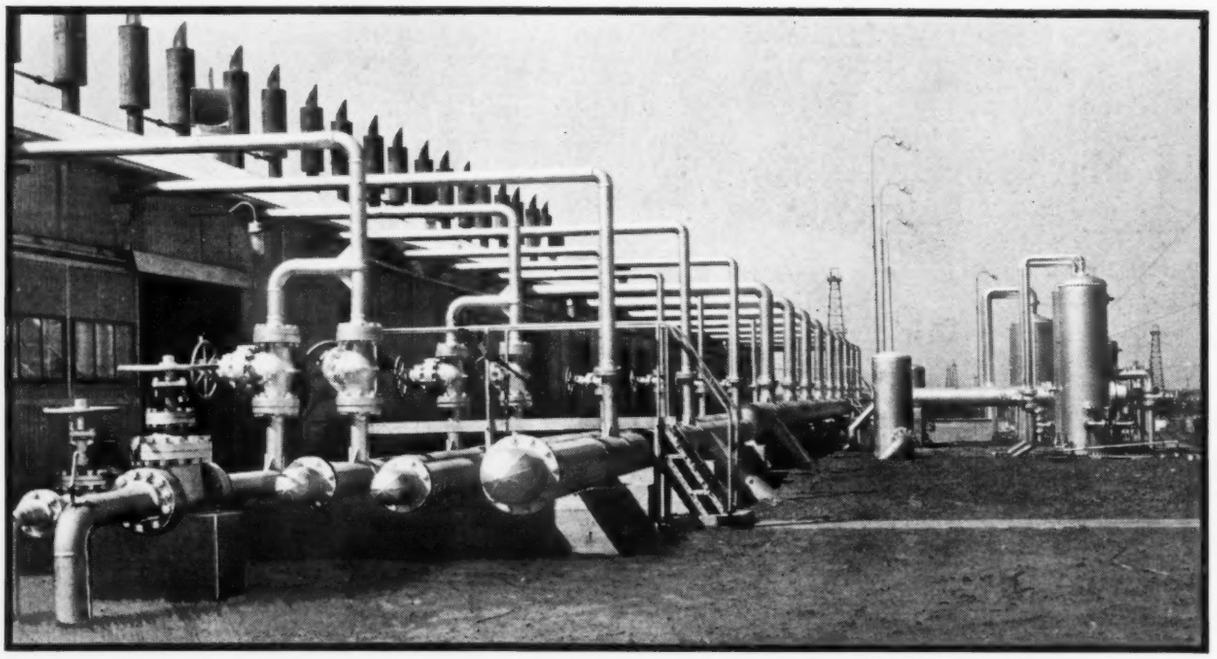
NATIONAL USS STAINLESS
AND HEAT RESISTING PIPE AND TUBES



Exterior view showing manifold connections, scrubbers, coolers and accumulators

Latest Oklahoma City Gas-Lift

Changing field conditions anticipated in lay-out of equipment

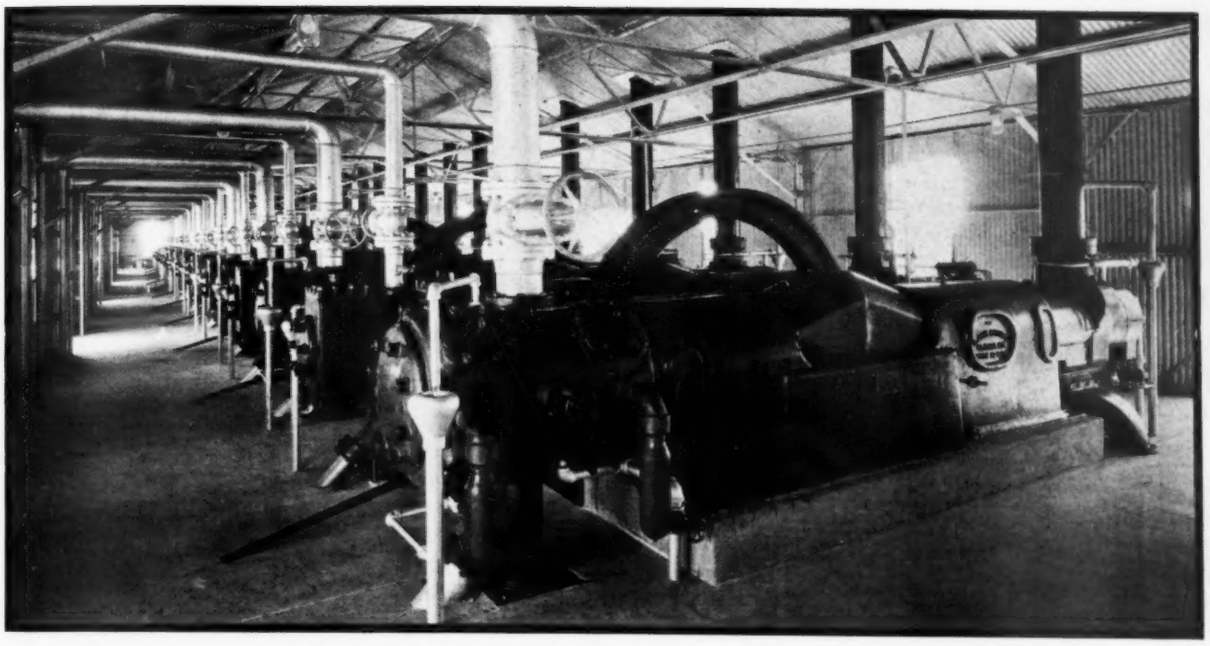
WELLS in increasing number are ceasing to flow naturally in the Oklahoma City field, a situation that confronts operators with the problem of producing their wells by some mechanical means in order to maintain production. The great depth to the producing horizons, water encroachment, and an ample supply of natural gas for artificial flowing, are factors in this field that seem to favor consideration of the gas-lift as a suitable method of production at this stage in the life of these wells; consequently, gas-lift plants of modern design for operating at high efficiency and having maximum flexibility to meet the constantly changing field conditions are being installed.

One of the most recent of these to be put into operation is the Wirt Franklin Petroleum Corporation's gas-lift plant on the Theimer lease. It is a model of compactness and embodies many improvements and desirable features that, besides being of general interest, are indicative of the progress that has been made in the last few years in the design and general layout of gas-lift machinery of this type. In this particular plant it is at once evident that much thought has been expended and foresight exercised in planning the details. A remarkable range of flexibility has been obtained whereby the plant can be operated continuously at a relatively high standard of efficiency under widely varying sets of field and operating conditions. Besides these advantages, simplicity of operation has been obtained.

The plant is of the three-stage compression gas-engine-driven type and is designed for a daily capacity of 15 million cu. ft. of gas at 10-lb. intake pressure and 750-lb. discharge pressure. Provisions have also been made for boosting the pressure from 750 to 1500 lb. on two of the compressor machines should it be needed for flowing or "kicking-off" wells under high pressure. The arrangement and capacities of the compressor units and the ample suction and discharge manifold are such that in case of a shut-down of any one unit the increased load on the rest of the machines running is so evenly distributed as to make the change in load hardly noticeable. Fuel gas for the compressor engines is brought direct from the well separator at 150-lb. pressure, the energy of which is first utilized in the turbines that drive the water circulating pumps. The water circulating and cooling system is designed for efficient engine and compressor operation under both summer and winter temperatures. Equipment to insure thorough scrubbing of the formation gas consists of scrubbers with liquid float-valve controls, and gas-coolers of the most modern type, both of which are of particular interest.

These are among the most important and interesting features of the plant that are worthy of more detailed description.

Compressors and Engines. There are 24 Clark Bros. Company compressors consisting of nine 16-in. low-stage, nine 8½-in. intermediate-stage, and six 5½-in. high-stage cylinders. These are cross-connected in pairs as follows: six 16-in. x 8½-in. x 20-in. (stroke), three 16-in. x 5½-in. x 20-in. (stroke), and three 8½-in. x 5½-in. (stroke) compressor machines. Each machine comprises a unit of two compressors direct-driven by a Clark Bros. Company 17-in. x 20-in. (stroke) Super-2 (two-cycle) twin gas engine of



Interior view of Wirt Franklin Petroleum Corporation's gas-lift plant in Oklahoma City field

By K. C. SCLATER

Plant of Modern Design

Total capacity of compressor units installed is 2760 B.HP.

230 b.hp., 200 r.p.m., fully enclosed and equipped with a full pressure-feed lubricating system. The twelve compressor engines have a total rated capacity of 2760 brake horsepower.

Referring to the accompanying sketch showing the lay-out of the plant it will be observed that no machine has two compressor cylinders of the same dimension; the arrangement, size, and combination of the compressor cylinders in the twelve units being such that should any one unit shut down, not more than one-ninth of either the low-stage or the intermediate-stage and one-sixth of the high-stage compressor capacity will be out of use. The overload thrown on the rest of the machines will be relatively small and, because of the ample capacity of the manifold system, automatically will be so evenly distributed that the effect of the overload on the other machines will be so slight as to be barely perceptible.

It was already stated that two units are equipped for boosting the gas to 1500-lb. pressure if necessary. The compressor cylinders of these units have adjustable clearance pockets by means of which a high volumetric efficiency can be maintained even when operating at this high pressure. The mechanism of the adjustable feature is a piston in the clearance pocket that can be adjusted by manual control to the proper clearance so that the volumetric efficiency of the compressor cylinder will not be impaired.

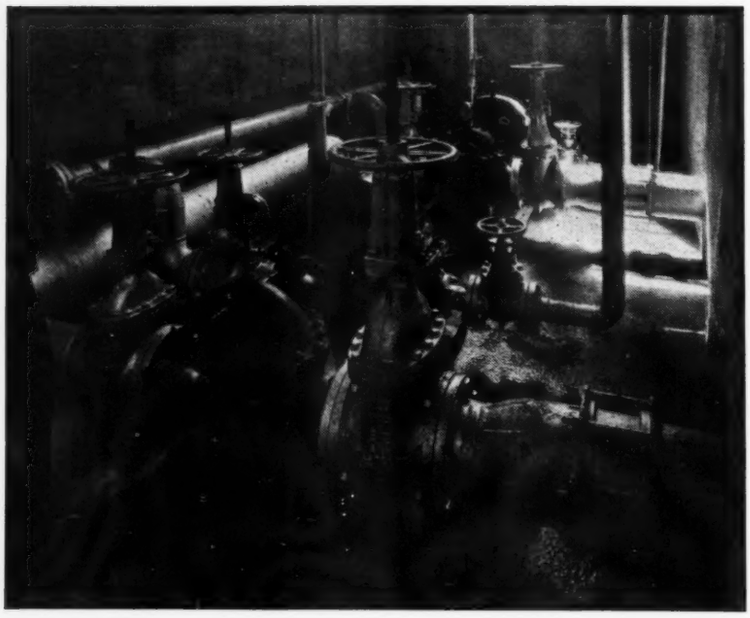
The low-stage compressor cylinders are so designed that adjustable clearance pockets can, if desired, be used for operation at any intake pressure below 10 lb., thus maintaining a high volumetric efficiency. The intermediate-stage cylinders are of the new box-type design for high volumetric efficiency. Both the low-stage and intermediate-stage compressors have Clark strip-type valves, but the high-stage compressors are equipped with Clark multiplate valves.

All compressor cylinders have a built-in bypass for use in starting; a pressure of only 100-125 lb. is required for starting instead of the 175 lb. usually needed. This advantageous feature, it should be noted, is incorporated in the design of the cylinder. A minor feature, but one worth noting, is the compressor cylinder discharge connections. These all come off at an angle of 45 deg. instead of the conventional 90 deg., thus eliminating two 90-deg. bends and possible leakage troubles arising therefrom.

Each machine is lubricated throughout by a full pressure-feed system by means of McCord wire sight-feed lubricators. The latter can be checked and adjusted while the unit is in operation and the oil consumption held to the minimum. The fact that the engines have an overhead exhaust also aids greatly in keeping the lubricating oil consumption low. Exhaust ports, the hottest part of the engine, are on top and are amply water-jacketed as is also the exhaust pipe itself for about 18 inches above the water jacket of the engine cylinder; overheating is thus avoided and the lubricating oil consumption kept low.

Both the power and the compresor cylinders are honed to add to their life and improve their efficiency. A built-in indicator motion on each engine permits the taking of indicator cards with ease.

Gas Compressions and Treatment. Gas is brought direct from the well separators to the plant through a 12-in. wet gas line field system. Before entering the 20-in. plant intake line the gas is passed through two 7-ft. x 22-ft.



Circulating water pumps driven by gas turbines

horizontal scrubbers. These are equipped with Fisher liquid float control valves for automatic dumping of accumulated condensate or other liquid. From the 20-in. intake line the gas is passed through four vertical 40-in. x 10-ft. scrubbers before entering the 20-in. low-stage suction header (see sketch). These vertical scrubbers are connected in multiple series of two and are also equipped with Fisher liquid float control valves. They have a combined capacity of 250 bbl. so that any excess liquid due to surging at the well can be adequately cared for and prevented from reaching the compresosrs.

From the low-stage intake header the gas is drawn into the low-stage compressor, then compressed to 70-80 lb. and discharged into the 12-in. 70-lb. low-stage discharge header. From here it is passed through a small vertical scrubber, then through the two horizontal low-stage coolers (Griscom-Russell enclosed type), where the gas is cooled to about 82 deg. fahr., thence through the low-stage accumulator (see sketch) and into the 12-in. intermediate-stage 70-lb. suction header. It is then compressed to about 280 lb. in the intermediate-stage compressor after which it passes into the 8-in. 300-lb. intermediate-stage discharge header. From here it passes through an oil scrubber, then through the two intermediate-stage Griscom-Russell coolers, where the heat of compression is removed and the temperature of the gas again reduced to about 82 deg. fahr., after which it goes through the intermediate-stage accumulators (see sketch) and on into the 8-in. 300-lb. high-stage suction header. The gas is then compressed to 750 lb. in the high-stage compressor, from which it goes to the 6-in. high-stage discharge header and thence to the field distribution lines. From the field distribution system the gas is returned to the wells down through the 2½-in. tubing.

As will have been observed in following its course through the plant, the gas is thoroughly scrubbed and denuded of its gasoline content. The gasoline is piped to a nearby casing-head plant after passing through a Moorlane scrubber.

In that section of the 20-in. plant intake line between the horizontal and vertical scrubbers a 12½-in. drip is inserted in the line. There are also a Davis relief valve, set at 10 lb., and two 8-in. relief lines to protect the 20-in intake line and header.

Fuel Gas. One of the unique features of the plant is the dual duty to which the fuel gas is put. The fuel gas is received direct from the well separator through a separate 4-in. line at 150-lb. pressure, the energy of which is used to drive a Terry turbine, which in turn drives the water circulating pump. After doing duty as a source of power in the Terry turbine the gas is then distributed to the compressor engines as fuel. The design of the water system is such that the volume of gas at 150-lb. pressure required to drive the turbine about balances the volume of gas (at 20-lb. pressure) required for fuel at the compressor engines. In the event of failure of the 150-lb. gas supply from the field, provision has been made for taking gas from the intermediate-stage header through a bypass equipped for this purpose with a regulator and control valve. Excess fuel gas in the line between the Terry turbine and the compressor engines is bypassed through a 6-in. line to the 12-in. wet gas field system.

Water Circulating System. All water for the plant is received in a concrete sump at one end of the building (see sketch). The pumps, of which there are two, set below the water level of the sump inside the main building, are 6-in. double-suction single-stage Pennsylvania centrifugal pumps having a capacity of 2000 g.p.m. against a 75-ft. head, and are direct driven by a 2400-r.p.m. 35-hp. Terry turbine. As was already stated, gas at 150-lb. pressure is used to drive the turbine operating with a 20-lb. back-pressure. Only one pump is in operation, the other being used as an alternate and standby.

All the water is pumped to a 14-louvre redwood cooling tower 64-ft. high, from which the water drains into a 1500-bbl. steel tank 24 ft. high. From this tank all the water used in the cooling system flows by gravity. The course of the water from the tank is through the dual Griscom-Russell coolers on the low-stage and intermediate-stage discharges and thence to the compressor and the engine water jackets. It should be noted (see sketch) that a 12-in. jacket-water inlet header and a 16-in. jacket-water discharge header are provided, the former laid alongside the gas manifold and the latter on the opposite side of the building. From the 16-in. jacket-water header the water drains into the concrete sump, there to be recirculated. Treatment of the water being used at present is found to be necessary to prevent scale deposition in the water jackets, and tannin briquettes, supplied by the Dearborn Chemical Company, are being employed for this purpose. Treatment is carried out in the sump or hotwell.

Changes in atmospheric temperature must be provided against in an open water cooling system. This item has been carefully worked out in this plant so as to maintain the engine jacket-water temperature within the range (95-115 deg. fahr.) for efficient engine performance.

The cooling tower has two secondary outlet connections on the standpipe, one at the first and the other at the fifth louvre, for cold weather operation. In addition, there is a 6-in. connection through which water can be bypassed from

the water line between the sump and the cooling tower into the jacket-water inlet header so that, even in the coldest weather, the cooling-water temperature can be regulated to any desired degree for efficient plant operation.

Safety and Other Miscellaneous Features. There are several safety features worthy of note. All engine exhaust pipes have an outer 12-in. casing. About one ft. above the jacket-water level and three ft. above the engine cylinder four holes (about 3 in. in diam.) are drilled in this outer casing. This establishes an up-draft of cool air, which aids in keeping the exhaust cool and also aids ventilation inside the building. Combined with the water-cooling, this arrangement keeps the temperature of the exhaust far below the ignition point of an explosive gas mixture, thereby eliminating a serious fire and explosion hazard. The engines are protected against break-down from lack of lubrication and high speed by a no-oil trip and an overspeed trip. No guard rails are necessary around the compressor and engine—except possibly for a small rail between the compressor cylinders for the flywheel. The engine and compressor are so designed that an adjustment of all bearings can be made in 2½ hours. To get at any one part no stripping is necesary; accessibility is a prominent feature of these machines.

Two eye-bolts are welded into the outer casing of the engine exhaust to receive a portable crane for use in taking off engine cylinder heads and in making general engine repairs.

The only auxiliary machinery besides the two pumping units for circulating water is an Ingersoll-Rand, type 30, radial air-cooled 5 & 3 x 3½ starting compressor, which is driven through a three-string Dayton V-belt by a Louis Allis Commany enclosed explosion-proof induction motor.

There are nine 15-lb. and one 50-lb. Fyre-Freez (liquid CO_2) fire extinguishers placed at convenient points throughout the plant.

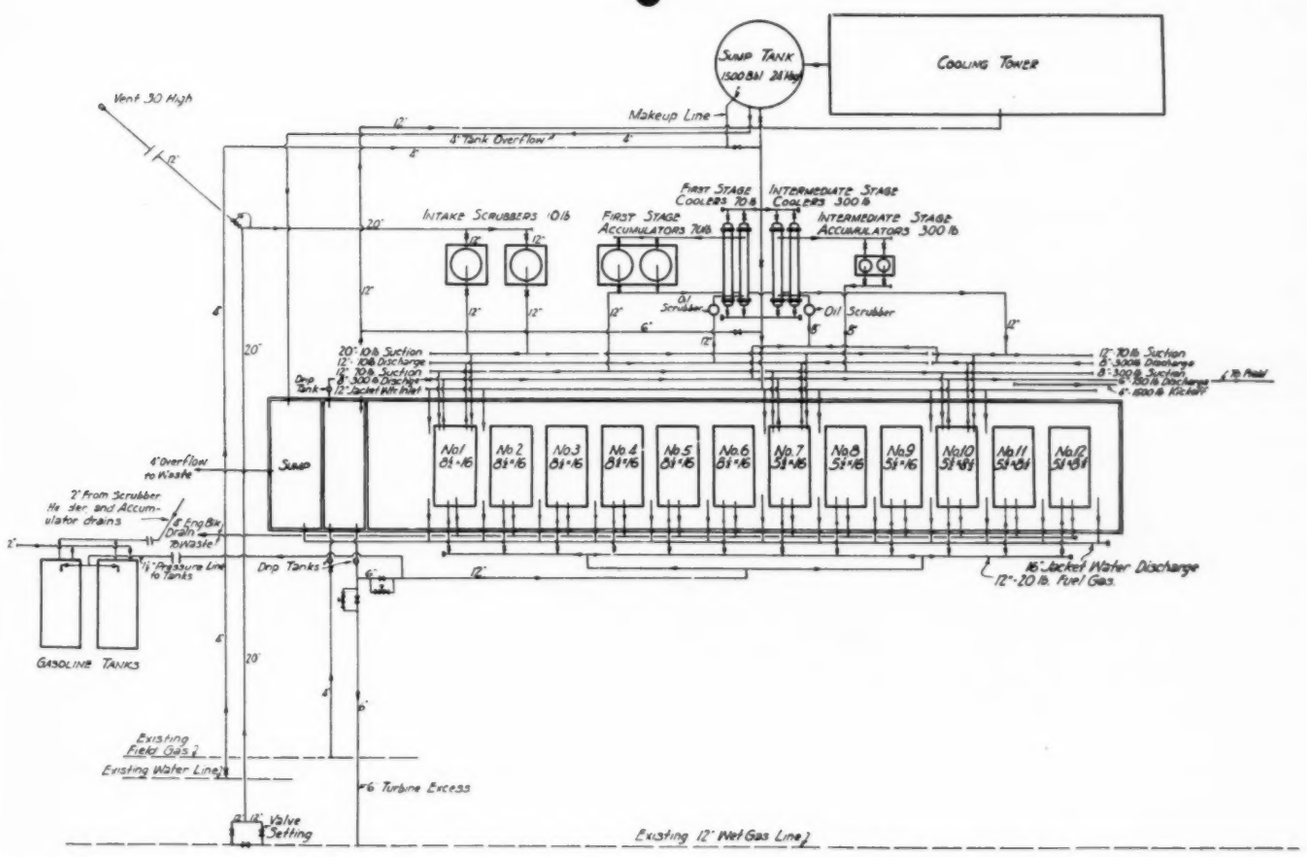
The compressors are housed in a 32-ft. x 200-ft. steel building. All machinery foundations and manifold supports are of concrete.

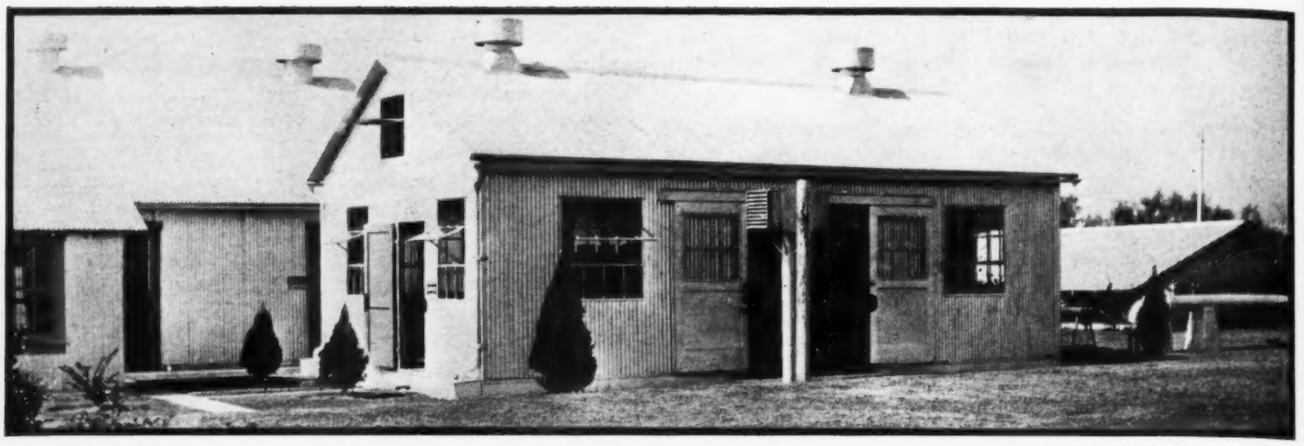
Gas-Lifting Operations. There are eight wells on the Theimer lease, six of which are being produced by the gas-lift. They are all in the Simpson Sand, produce 85-90 per cent water with the oil, and are flowed through the annular space between the 2½-in. tubing and the casing from a depth greater than 6000 feet. Early in October these six wells were producing a total of 6000 bbl. of fluid (oil and water) daily with an input gas volume of about 16 million cu. ft. and a formation gas volume of about 6 million cu. ft. at about 500-lb. plant pressure. The plant was therefore handling some 16 million cu. ft. of gas daily, 10 million cu. ft. of which was recirculated gas and 6 million formation gas, from which 1500-2000 gal. of casinghead gasoline was being recovered. The only processing that the gas went through before being returned to the wells was that described herein.

The plant layout is so designed that three additional units can be installed and the capacity increased without altering the header system other than extending it and adding another horizontal heat exchanger for the gas.

Clark Bros. Company were awarded the contract for the complete installation of the plant and sublet the construction work to J. F. Pritchard & Company, Kansas City, Mo. E. J. McKee, petroleum engineer for the Wirt Franklin Petroleum Corporation, had direct supervision of the installation of this plant for the company and is responsible for its operation.

General layout of Wirt Franklin Petroleum Corporation's gas-lift plant in Oklahoma City field





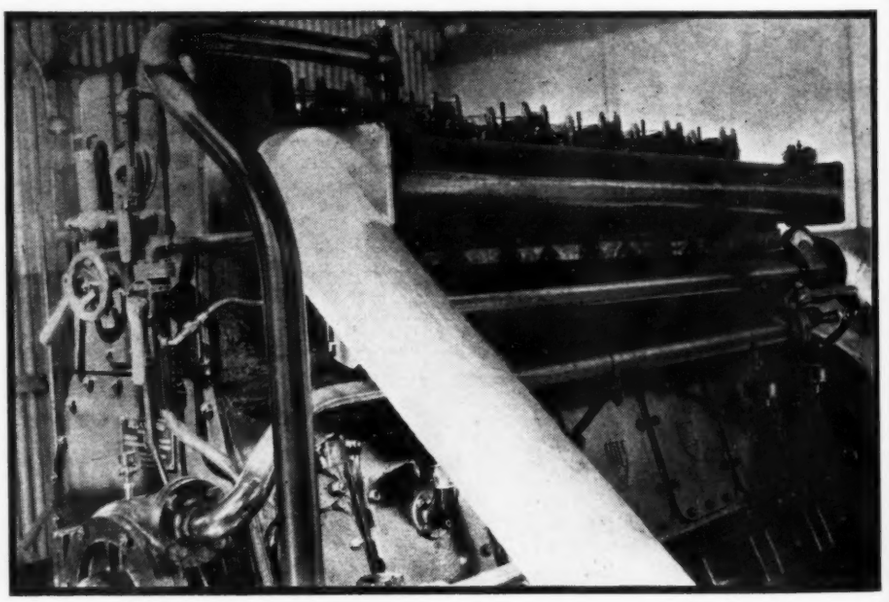
High-pressure unit at Bullock Station in foreground

How Flexibility of Field S Was Improved on Stanolind

ALTHOUGH classified as a field station, the Bullock Pump Station, Limestone County, Texas, of the Stanolind Pipe Line Company is one of the most important key or control centers on the company's gigantic transportation system, the trunk line of which extends from Houston, Texas, to Chicago, Ill. A high-speed high-pressure pump unit enables the station to deliver crude either through the Mexia, Texas, trunk line station, which is located approximately six miles away, or direct into the trunk line by by-passing the Mexia station. This set-up provides the system with remarkable flexibility, in that should the Mexia station be pumping oil south to Houston, and it be found necessary to move oil northward from Mexia at the same time, the discharge from the high-pressure unit at Bullock may be by-passed at Mexia and sent directly north to the Lakenon station. The direction of pumping may be reversed if necessary and the Bullock station's discharge sent south towards Houston; in other words, the Mexia station can pump one way, either north or south, while crude from the Bullock station may be pumped in the opposite direction.

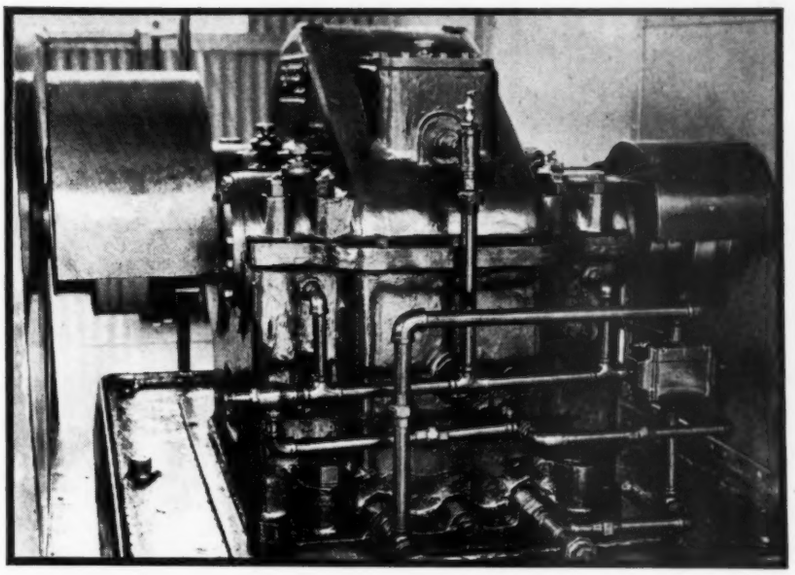
In addition to having this flexible arrangement, the station has several other interesting and significant features. Among these are its unchallenged claim to the honor of being the first, and still one of the few, installations the pumping units of which consist of a high-speed high-pressure pump driven through a gear increaser by a high-speed Diesel engine. The growing burden of handling more and more oil that was placed upon this small, 12-year-old station resulted in its being remodeled two years ago and the high-speed engine added, by which addition Bullock developed into a large station. Stanolind Pipe Line Company officials and employees are proud, and justly so, of the growing importance assumed during the past two years by the station. All the oil shipped from the East Texas field by the company is handled through this station and explains why, although not a main line station, it was deemed advisable to equip it with machinery capable of providing facilities commensurate with the important control position it occupies.

The Bullock station was originally constructed to deliver oil to the Mexia main line station from the Chambers Creek field and also to service the huge tank farm in which it is located. When first erected, the pumping units consisted of a 140-hp. De La Vergne single-cylinder Diesel driving two Gaso 10x18 reciprocating pumps. These are capable of han-



Light, high-speed Diesel installation at Bullock Station

Added facilities of Bullock Station enables company to pump East Texas crude north and south at same time. It was the first light, high-speed Diesel-centrifugal pump station



Gear increaser used at Bullock

Station Pipe Line System

By WARREN L. BAKER

dling daily from 25,000 to 30,000 bbl. each, and are still in service, being used to deliver crude to the Mexia station. Like the newer high-pressure unit, they now pump East Texas oil exclusively. With these two units still in dependable operation, the Bullock station has both low-pressure and high-pressure pumping units. The two types of pumps are housed in separate buildings with their prime movers.

The high-speed Diesel is a vertical, six-cylinder type that develops 300 hp. at 750 r.p.m., and weighs only approximately 33 lb. per horsepower. Its light weight and compactness are such that a small foundation and little space are required for installing, and permit handling much more readily and easily than the heavier units. Enforced shutdowns are costly occurrences in pipe line station operation and their avoidance becomes an important factor. For example, in a five-day period, an old engine at Bullock station was completely dismantled and a new one installed and placed in operation.

The engine is operated on whatever type of crude is being pumped, the fuel being taken from the line and delivered to a fuel tank preparatory to delivery to the engine. As a safety precaution, the main engine lubricating system has been equipped with an automatic stop control designed by J. B. Harshman of the Stanolind Company. In the event of a failure of the lubricating system, the control will immediately shut down the engine. This safety automatic stop control is designed to accomplish this by depending upon the pressure of the lubricant passing through the feed lines to hold open a fuel valve; when the pressure in the lubricating feed lines drops below a definite limit the valve automatically closes and shuts down the engine.

The engine speed of 750 r.p.m. is increased to 3500 r.p.m. on the Goulds pump by means of a Farrell gear increaser, an arrangement whereby the pump discharge is capable of bucking a pressure up to 475 lb. pressure. However, the Diesel-centrifugal pumping unit may readily be regulated to suit the required pumping conditions. At Bullock, no difficulties have been experienced in adjusting the pump delivery to transportation requirements, which is accomplished, without great sacrifice of operating economy, by a combination of speed reduction and throttling. When delivering to the Mexia station the Bullock station discharge pressure is usually 200 lb., but when by-passing Mexia the normal discharge pressure is between 375 and 400 pounds.

This station, of radical departure from the usual design, has given a highly satisfactory account of itself, both mechanically and economically. It has fulfilled all expectations and, except for the occasional interruption in service experienced with any type of machinery, it has given dependable service.

The design of the station water circulating system is of the closed type, in which the crude passing through the station is used for cooling by means of a suitable heat exchanger built into the discharge line. The water pump, driven by a belt drive from a take-off on the shaft end of the engine, circulates the fluid from the engine to the extreme end of the exchanger where the stream is discharged through the cooler counter-current to the flow of crude passing through the tubes. From the exchanger, the water is returned to two 150-bbl. water tanks, the output from which is delivered by gravity to the engine. Water leaving the engine has a temperature of 135 deg. fahr., which, by the time it is returned to the tanks, has been cooled to 96 deg. fahrenheit.

The lack of standby equipment in a station of this importance, at first glance, may appear to be a serious omission. However, it must be borne in mind that Diesel engine performance is much more reliable today than a number of years ago when most of the pipe line stations were constructed. Likewise, it must be remembered that at Bullock the existence of the old low-pressure units assure that movement of East Texas oil from the field will not entirely cease due to a breakdown in the high-pressure pumping unit.

A feature that is not to be overlooked in the installation of a pumping station of this type is that the equipment can be readily dismantled and moved to another location. It is natural to expect that some day the volume of shipments from the East Texas field will be materially lower than they are today. When this time arrives the Stanolind Pipe Line Company may find it desirable to move the equipment at Bullock elsewhere; but this will not be a difficult task because of the light weight and small overall size of the equipment.

Using Hygroscopic Salts in the Refineries of Continental Europe

By ROBERT SUNDER
Refinery Chemist

HYGROSCOPIC salts are used for the dessication of petroleum in the refineries of Continental Europe, including the refineries of Pardubitz (Bohemia), Ustrzyki-dolne (Galicia), Kolin (Bohemia), Pechelbronn (France, Alsace-Lorraine), and others. The refineries in Galicia use the heat of the later distillates for the first heating of the petroleum and dessicate subsequently. Oil without dessication would cause heavy knocking.

Formerly, chloride of magnesium, supplied by German mills, was generally used for the purpose in question. Today, chloride of calcium is frequently used, for instance, in such cases where chloride of magnesium, on account of high import duties, is too expensive in comparison with home-manufactured chloride of calcium. The refineries of Pechelbronn use today chloride of magnesium made by a big French chemical concern, the Société des Produits Chimiques d'Alais et de la Camarque, who manufacture at its factory at the mouth of the river Rhône, chloride of magnesium, the production of which is protected by high French import duties.

TABLE I

Chloride of Calcium

Chloride of Calcium	70 to 72 per cent
Chloride of Sodium	1 to 2.0 per cent
Burnt Lime	0.222 per cent
Sulphate of Calcium	0.120 per cent
Sulphurous Lime	0.060 per cent
Chloride of Magnesium	0,057 per cent
Carbonate of Magnesium	0,007 per cent
Ferric Oxide / Aluminum Oxide	0.015 per cent
Insoluble	0.040 per cent
Water	Balance
	100.00 per cent

Chloride of Magnesium

Chloride of Magnesium	45.04 per cent
Chloride of Potassium	1.75 per cent
Chloride of Sodium	0.85 per cent
Magnesium Sulphate	0.30 per cent
Insoluble	0.10 per cent
Water	51.96 per cent
	100.00 per cent

The requirements in chloride of magnesium or chloride of calcium vary rather widely in the different refineries. For instance, one particular refinery uses about 100 tons of chloride of magnesium per year. Besides the question of price there are still other details that influence the preference for one of these salts. It is especially interesting to compare the analyses of the two chemicals, as per Table I.

The analysis of the salts represents the average commercial quality. Generally speaking, chloride of magnesium and chloride of calcium will usually be found to be identical with these analyses. Small deviations are, of course, possible in such technical products. Chloride of magnesium will sometimes have up to 48 per cent $MgCl_2$, chloride of calcium up to 75 per cent $CaCl_2$.

The price of the salts on the Continent is in relation to the hygroscopical effect of the contents. In other countries, freight rates and import duties have an influence, so that a special calculation is in each case of advantage.

Both salts are used for dessication of petroleum by preference in the fused form, in solid blocks of about eight to ten cwt., which may be reduced to smaller pieces as considered expedient.

Another use of the salts referred to is made in the manufacture of paraffin wax. In this case, the distillates are first cooled by air, while the paraffin wax is then obtained by freezing down to about 10 to 15 deg. cent. below freezing (or plus 14 to plus 5 deg. fahr.). The salt solution in the refrigerating machine is usually kept at a temperature of 20 deg. cent. below freezing (or minus 4 deg. fahr.).

For the making of the brine, the salts are preferably dissolved by using ordinary spring water. The circulating brine must be absolutely pure to avoid the choking of the pipes. It is therefore best to proceed as follows:

A strongly concentrated solution is made by adding to the salts as small a quantity of water as possible. The brine is then drawn off and the residues considered as waste. These residues are all those other salts indicated in the analysis, insoluble substances, etc., which, otherwise, might choke up the pipes in the course of time.

Usually the circulating brine is controlled by a stationary aerometer; strongly concentrated solution will be added to the brine to maintain always the right density, whenever this is found necessary.

For economical reasons, the brine should be only so dense as absolutely necessary for the purpose in view. Tests with brines of the same density gave the following results:

A 10 per cent brine of chloride of calcium will freeze at minus 5.9 deg. celsius, or 21 deg. fahrenheit.

A 10 per cent brine of chloride of magnesium will freeze at minus 11 deg. celsius, or 12 deg. fahrenheit.

A 20 per cent brine of chloride of calcium will freeze at minus 11.7 deg. celsius, or 12 deg. fahrenheit.

A 20 per cent brine of chloride of magnesium will freeze at minus 27 deg. celsius, or 17 deg. fahrenheit.

In order to obtain the same cooling effect, a solution of chloride of magnesium can thus be half as dense as a solution of chloride of calcium.

Practical experience has resulted in finding that both salts have the same properties regarding the corrosion of iron. Choking of the pump is easily avoided by dissolving the salts in the above-mentioned manner. Usually the price will decide which salt is to be preferred, taking, of course, into consideration the percentage shown by the analysis and the density necessary to reach the respective degree below freezing point.

In practice, the brines are kept a little denser than calculated for the required degree, to compensate for unforeseen losses in the piping system, etc. These losses in brines of chloride of calcium are 2 to 8 per cent, in chloride of magnesium 1 to 8 per cent.

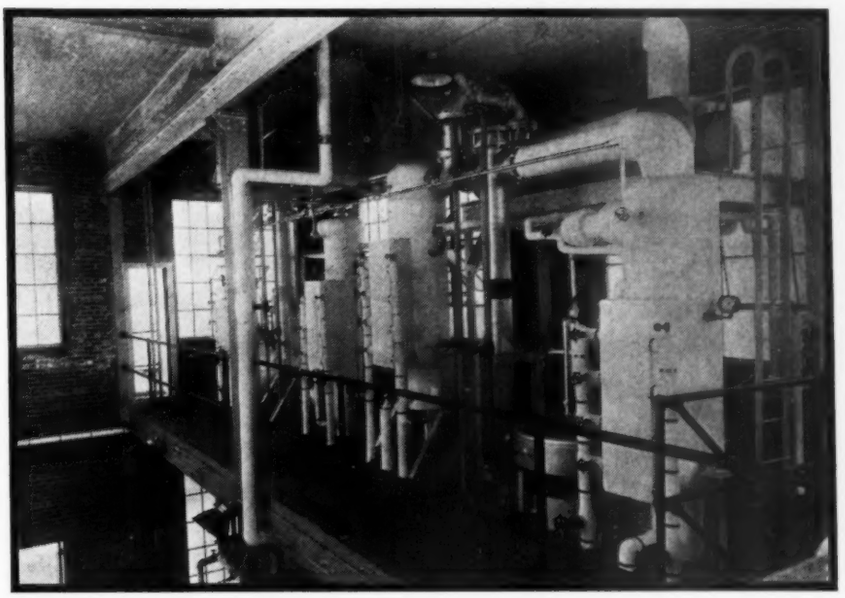
The losses are more important in brines of higher density. Generally speaking, the solution must be selected so that the freezing point of the brine may be about five degrees below the cooling point absolutely necessary. The refrigerating plant will then not show unforeseen interruptions by sudden losses, causing the freezing of the brine.

For practical reasons, the density of the brine is controlled by the aerometer, which is based upon degrees Baumé (not to be confounded with Réaumur). The Baumé degrees show immediately the density by the aerometer sinking more or less into the brine. A table indicating the concentrations of the brine necessary to obtain the respective low temperatures will be of much help and facilitate the task of the operator.

The Duo-Sol Process of Solvent Extraction for the Manufacture of Lubricating Oil

THE Duo-Sol Process of solvent extraction for the production of lubricating oils is unique in that instead of employing a single solvent or a mixture of solvents that are selective alone for the naphthenic fractions, two immiscible solvents are employed, one of which is selective for the paraffinic oil, the other selective for the naphthenic fractions.

The operation of the Duo-Sol extraction unit is somewhat analogous to that of a fractionating column except that it is carried on in a liquid phase and depends upon the solvent power of the reagents employed instead of the boiling range of the fractions to be separated. The two solvents pass countercurrently to each other through the system. The charging stock is fed to the center of the system and as it is separated into the paraffinic and the naphthenic fractions these two constituents flow countercurrently to each other along with their respective solvents. Thus the paraffinic solvent is continually stripping the naphthenic fraction of its final traces of paraffinic oil in the same manner in which steam is used for the stripping of fractionating tower bottoms. Simultaneously, the naphthenic solvent continuously washes the last traces of naphthenic oil from the paraffinic fractions and, in consequence, acts in the same manner as reflux in a fractionating column.



Interior of Duo-Sol pilot plant showing solvent recovery equipment.

It would appear that if this principle of operation is essential in a fractionating column, it would be of even more importance wherein liquids are being handled and separated by virtue of the solvent action of the reagents employed. In any event, it is a principle that has been responsible for some rather interesting results, the principal ones of which are listed as follows by Max B. Miller & Co., Inc., licensors:

(a) It permits the refiner to treat without prior refining steps the cheapest charging stock available from any given crude, i.e., a long residuum or a steam refined stock.

(b) It produces therefrom a paraffinic lubricant of excellent quality. The oil has a high viscosity index and a low viscosity-gravity constant. It is particularly resistant to sludging as a result of oxidation and is extremely low in carbon residue.

(c) The paraffinic oil discharged from the Duo-Sol plant ranges in color from four to seven on the N.P.A. scale, depending upon the nature of the charging stock, and may in any case be brought to final color by filtering and without the use of acid and/or subsequent neutralization.

(d) It is responsible for maximum yields of paraffinic oil from any given charging stock and because it is suitable for the treatment of residuums, it permits the maximum yield of paraffinic oil from any given crude. This is exemplified by the fact that the specific gravity of the naphthenic fractions when separated from a residuum will range from 1.035 to 1.06 depending upon the nature of the charging stock.

(e) It permits the refiner to produce from any given Mid-Continent crude a yield of high-grade lubricant.

(f) It reduces the cost of lubricant production. This is due to two facts: one, it does not depreciate the value of the charging stock in either of the separated fractions and, two, it materially reduces the cost of bringing the oil to final color.

The Duo-Sol Process is the result of several years' research, which has culminated in the erection and the operation of a pilot plant by which the effectiveness of the process when applied to any charging stock might be clearly demon-

TABLE NO. 1

Ranger-Burbank long residuum, Duo-Sol extracted and dewaxed yielding 78.4% paraffinic oil before dewaxing and 21.6% naphthenic tar having a specific gravity of 1.045.

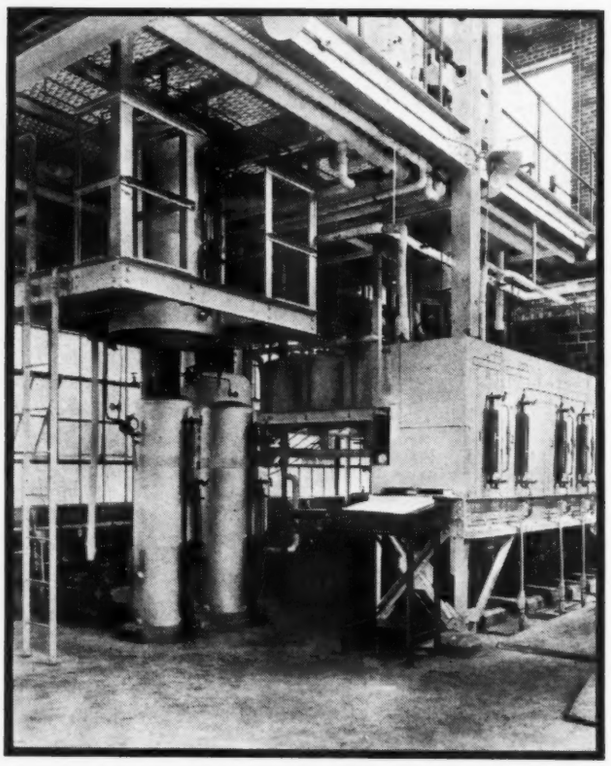
	Original stock	*Paraffinic oil*	*Paraffinic oil after dewaxing*
Gravity	23.5	30.1	29
Flash	450	450	450
Fire	500	500	500
Viscosity at 100	.....	.....	509
Viscosity at 210	84	62	65
Viscosity index	.....	.....	100
Viscosity-gravity constant	.848	.803	.810
Pour	.....	100	20
Color	.....	6 N.P.A.	6 N.P.A.
Carbon residue	.....	.....	.23

TABLE NO. 2

Hendricks long residuum, Duo-Sol extracted, yielding 49.3% Paraffinic oil and 50.7% naphthenic tar.

NOTE: Since the paraffinic oil contained only a cloud, it was not subsequently dewaxed.

	Original stock	*Paraffinic oil*
Gravity	16.8	27.6
Flash	455	455
Fire	505	490
Viscosity at 100	.....	550
Viscosity at 210	147	67
Viscosity index	.....	100
Viscosity-gravity constant	.886	.817
Pour	.....	+5
Cloud	.....	48
Color	Black	5 N.P.A.
Carbon residue	.....	.15



Interior of Duo-Sol pilot plant showing extractor units in foreground.

strated on a semi-commercial basis. The design and the erection of the pilot plant has been carried out in complete detail. It has been built so as to incorporate every phase of a commercial extraction plant employing such a process inclusive of both the extraction unit itself and the equipment necessary for the recovery of the solvents. Since completion it has been in continuous 24-hour operation. No less than 18 different types of charging stock have been treated in the pilot plant. Its operation, however, has not only served as a guide to results obtainable from a given crude but has been utilized as a basis for the design and erection of commercial plants now in the process of construction.

There are many solvents that are selective for both the paraffinic and naphthenic oils that are available to the Duo-Sol Process for, after all, the process has been developed around a principle rather than because of the use of some particular reagent. However, for the present at least the use of propane is recommended as a solvent for the paraffinic oils. It is cheap; it is readily available to all refiners; it is highly effective and easily recovered. For the naphthenic solvent a special blend of coal tar acids and bases with a boiling range of from 360 deg. fahr. to 405 deg. fahr. is recommended. This material is low in price and is available in the quantities required. It is effective at normal temperatures and is easily recoverable. It is exceptionally stable and has no tendency to decompose in the oil during the process of its recovery.

TABLE NO. 3

Motor oil blends prepared from Ranger-Burbank long residuum solvent treated by the Duo-Sol Process and percolated 3:1 through No. 6 Attapulgus clay.

	Overhead	*Reduced*	*SAE 20*	*SAE 30*	*SAE 40*	*SAE 50*	*SAE 60*
Gravity, °A.P.I.	30.3	27.2	29.3	28.5	28.5	28.0	27.2
Flash, °F.	415	525	430	445	445	470	490
Fire, °F.	475	610	490	505	505	525	580
Viscosity at 100° F.	190	1653	370	565	632	795	1293
Viscosity at 210° F.	47	119	58.6	68.4	72	82.4	106
Viscosity index	105	97	105	101	100	102	101
Color—Lovibond	1	59	20	35	38	41	56
Color—N.P.A.	1½	4½	3½	4	4	4	4½
Viscosity-gravity constant	.819	.807	.808	.809	.808	.808	.809
C.C.	.01	.31	.11	.18	.18	.25	.31

In order that the effectiveness of the Duo-Sol Process may be judged, the characteristics of the charging stock and of the paraffinic oil produced from it in the case of two types of crude are tabulated in Tables 1 and 2. These particular results have been selected for tabulation here for the reason that the charging stocks are extreme in their characteristics. The Ranger-Burbank residuum is high in gravity. It is a stock containing little asphalt. It is fairly high in wax but it permits a high yield of finished dewaxed oil having a viscosity index of 100. On the other hand, the Hendricks residuum is from a crude that is being run to asphalt and from which low cold test naphthenic lubricants are produced as an overhead product. It is consequently low in wax and in paraffinic oils.

Since the Duo-Sol Process is essentially a physical one in which the constituents existing in the charge oil are separated one from the other, the effectiveness of the process when applied to any residuum may be judged by the results tabulated here. The yield of the paraffinic oil procurable from any given stock may be judged by its gravity or its viscosty-gravity constant. The higher the gravity or the lower the viscosity-gravity constant, the higher the yield of paraffinic oil to be procured from a given charging stock.

The effect of fractionating and reblending a Duo-Sol treated stock so as to produce a full line of motor oils is a matter of some interest. A portion of the paraffinic oil produced from the Ranger-Burbank residuum as shown in Table 1 was reduced by distillation to a bottom having a viscosity of 119 sec. Saybolt at 210 deg. fahrenheit. The resulting overhead had a viscosity of 47 sec. Saybolt at 210 deg. fahrenheit. These two stocks were then blended in various proportions so as to produce a full line of motor lubricants. The characteristics of both fractions resulting from the distillation and of the various oils resulting from the blend of the two stocks are tabulated in Table 3.

It has been stated that the Duo-Sol Process was responsible for a high yield of paraffinic oil. This fact has been exemplified by a study of the characteristics of the naphthenic oil that has been separated from the original charging stock. For this purpose the naphthenic oil separated from the Ranger-Burbank residuum, which in itself is highly paraffinic, was given particular study. The mixture of asphalt and naphthenic oil as discharged from the Duo-Sol Process had a specific gravity of 1.045. Six and a half per cent of this tar was taken overhead by distillation so as to produce a clean cut naphthenic oil free from asphalt. As a result of this distillation the asphalt had a penetration of 50. The characteristics of the overhead cut were then determined and are tabulated as follows:

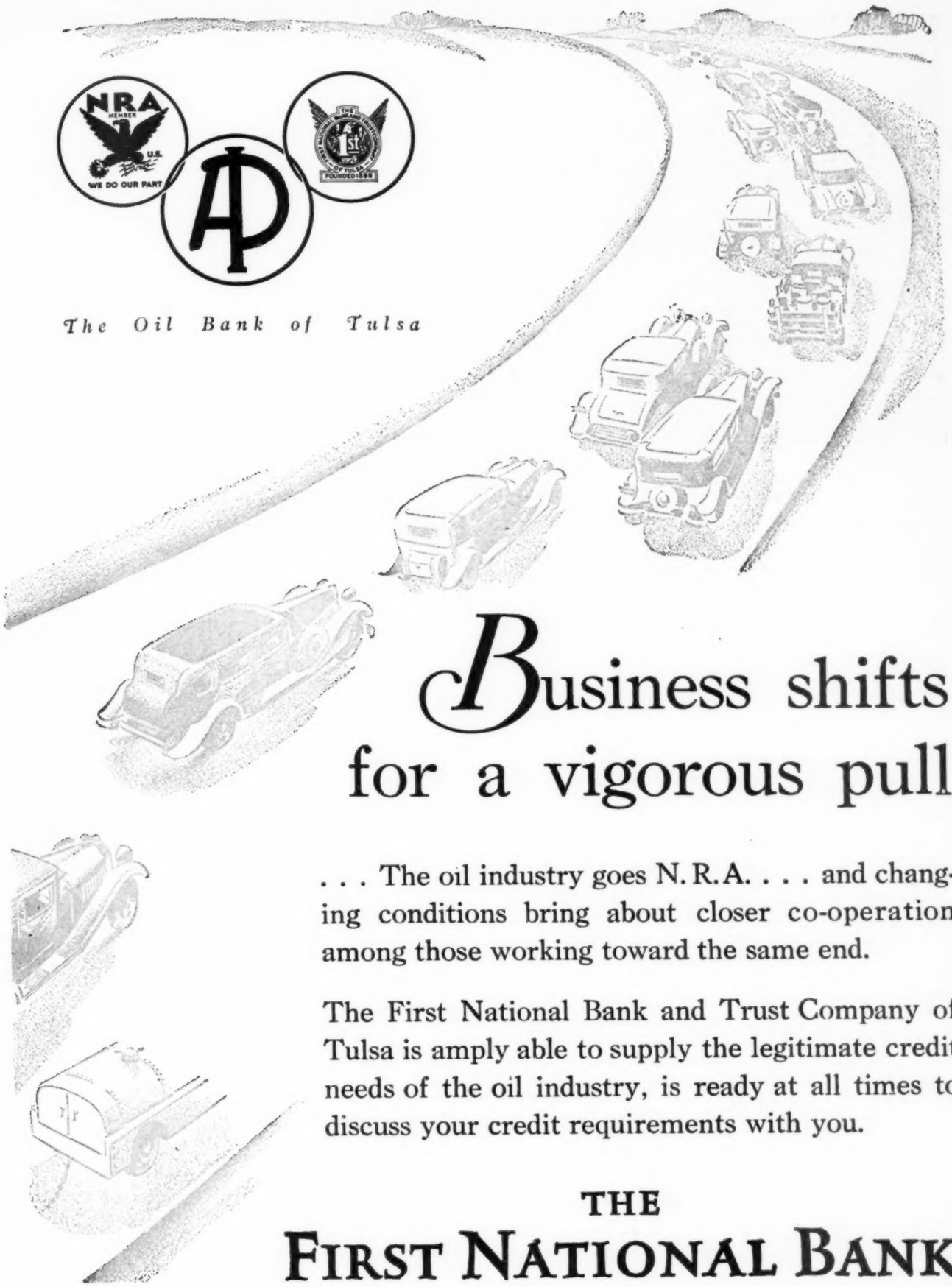
Specific gravity	1.042
Flash, Cleveland open cup	250
Saybolt viscosity at 130	257
Saybolt viscosity at 210	51
Viscosity index	Below —50
Pour test	25
Carbon residue	.31

Note the pour test of the oil because of extremely high viscosity at low temperatures.

One of the important, if not the most important, features of the Duo-Sol Process comes from the fact that oils may be finished with only a clay treatment.

The Socony-Vacuum Corporation has taken license under the Duo-Sol patents and has also awarded contracts to Max B. Miller & Co., Inc., for the design and erection of two Duo-Sol plants, one to be installed at the Vacuum Company's refinery at Paulsboro, New Jersey, the other to be installed at the Magnolia refinery at Beaumont, Texas. The total capacity of the plants to be such as to take care of the entire motor oil lubricating requirements of this company.

The Gulf Refining Company has also taken license under the Duo-Sol patents and has commissioned Max B. Miller & Co., Inc., to design a commercial plant for erection in the company's Philadelphia refinery.



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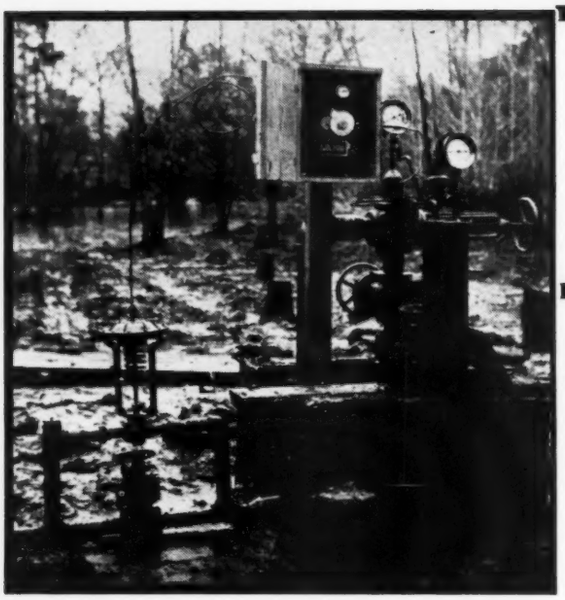


Regulator on East Texas well for automatic intermittent operation by natural flow

Flowing in the East

By S. F. SHAW
Consulting Engineer

CONSIDERABLE attention is now being given to conditions affecting the production of oil by flowing methods in the East Texas field. Flowing methods include both natural and artificial flow, since the principles governing both are identical. Natural flow usually precedes artificial flow as long as that method will produce all the oil that is allowed to be produced, because of the lower expense attached to the operation. When natural flow ceases, or when this method will not produce all the oil that the operator desires to produce, some form of artificial lifting method is installed, such as artificial flow, swabbing, or some form of pumping equipment.

There is no need at the present time of installing a method for increasing production beyond that being obtained, so long as natural flow continues, unless this be done merely to be prepared for the time when natural flow ceases, since in most wells of the East Texas field natural flow can produce as much or vastly more oil than is allowed to be produced. However, there has been much speculation regarding when natural flow can be expected to cease and when artificial methods must be adopted. Up to the present about 1000 wells are reported to have ceased flowing naturally and probably this number will gradually increase in the course of time.

Considerable information has been furnished by Ben E. Lindsly[1] concerning the quantity of gas dissolved in East Texas oil under certain conditions of pressure, also concerning the ft-lb. of work available in this gas when it becomes freed from the oil and expands to lower pressures. These figures provide a basis on which to approximate the bottom-hole flowing pressure combined with a given back pressure when natural flow will cease and when artificial flow will be necessary in order to continue the lifting operation. Lindsly determined that the ft-lb. of work given in Table 1 are made available when the gas in the East Texas oil is released from solution at 90 deg. fahr. under pressure of 638 lb. per sq. inch.

From Table 1 it will be seen that with a back pressure of 55 lb. absolute at the well-head there is as much energy left undeveloped in the gas as it leaves the well as is developed in expanding from 638 to 55 lb. per sq. inch. These figures can be employed by which to determine the approximate bottom-hole flowing pressure at which the wells will cease to flow in this field as shown in Table 2.

In Table 2 it is shown, for example, that with a bottom-hole flowing pressure of 915 lb. absolute and with a back pressure of 75 lb., the number of ft-lb. required to lift one bbl. of oil is 473,000; the number of ft-lb. available in the gas dissolved in one bbl. of oil in expanding from 915 to 75 lb. is 746,000, therefore, there is sufficient gas in the oil to continue natural flow under these conditions. However, it will be seen in the table that when the bottom-hole flowing pressure declines to 755 lb. if the back pressure is maintained at 75 lb. there will not be quite sufficient gas in the oil to lift it to the surface. The quantity of gas dissolved in one bbl. of East Texas oil at 755 lb. is approximately 370 cu. ft. and there is enough energy in 370 cu. ft. of gas to lift a barrel of oil until the bottom-hole pressure has declined to almost 500 lb. provided the back pressure be held at 14.4 lb. absolute —that is, atmospheric pressure.

In lifting oil unmixed with gas, a back pressure of 45 lb. would require a greater number of ft-lb. of work than if the back pressure were 40 lb. However, it is usually the case that the velocity of the mixture of oil and gas at the top of the flow string is higher than necessary and sets up excessive friction losses, and the application of back pressure tends to reduce this velocity. Sufficient data are not available, however, to determine whether increased back pressure requires a greater number of ft-lb. of work owing to this compensating factor of reduction in the velocity.

It is assumed in Table 2 that the correct diameter of flow pipe is employed for the quantity of oil that is lifted. The impracticability of having exactly the correct size of flow

TABLE 1

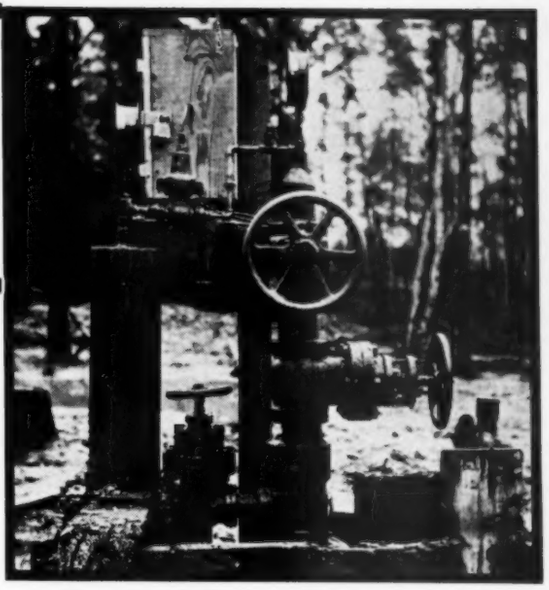
Ft-lb. of work developed by the expansion at 90 deg. fahr. of the gas dissolved in one cu. ft. of East Texas crude oil.

Expanding in lb. per sq. in.		Ft-lb. per cu. ft. of oil		Ft-lb. per bbl. of oil*
From	To	Actual	Cumulative	Cumulative
638	175	58,500	58,500	328,000
175	132	22,100	80,600	453,000
132	95	32,700	113,300	636,000
95	75	19,600	132,900	746,000
75	65	14,100	174,000	825,000
65	55	17,300	164,300	923,000
55	45	18,000	182,300	1,024,000
45	40	15,300	197,600	1,110,000
40	14.4	131,200	328,800	1,846,000

*This figure is found by multiplying by 5.615 the cumulative ft-lb. of work in the gas dissolved in 1 cu. ft. of oil.

[1]Ben E. Lindsly "A Study of Bottom Hole Samples of East Texas Crude Oil," paper read before the American Petroleum Institute, May 18, 1933, at Tulsa, Oklahoma.

Methods Texas Field



Hook-up of casinghead connections for producing well by intermittent natural flow

tubing would probably result in the flow tending to cease at bottom-hole pressures somewhat higher than those given in the table.

The quantity of oil and gas that will flow into the well is influenced by the permeability of the sand as well as by the back pressure set up on the sand by the flowing pressure; consequently, permeability of sand must be considered as well as diameter of tubing when considerations arise concerning the quantity of oil to be lifted.

Artificial Flow. After the well ceases to flow naturally, artificial flow can be continued merely by adding from a compressor plant enough gas to make up the amount of natural gas the well is deficient. In consequence of a comparatively large quantity of energy being present in the natural gas, especially in the early life of the well while pressures are relatively high, there may not be much additional gas required to continue the well in a flowing condition; consequently, for a considerable length of time the compressor capacity required will involve only a comparatively small outlay.

The approximate volume of compressed air or gas in addition to the 370 cu. ft. of gas dissolved in the oil required to lift one bbl. of oil in the East Texas field when continuous flow is employed under various conditions of bottom-hole pressure and of back pressure at the well-head is given in Table 3.

The cost of compressing gas under these conditions when using gas or oil engines would probably be somewhere between two and three cents per 1000 cu. ft., on which basis the cost for lifting oil with a bottom-hole pressure of 115 lb. absolute (gauge pressure of 100 lb.) and with atmospheric pressure at the tubing-head would be 4.8 to 7.2 cents per bbl. oil until the time that water enters the well with the oil. Over a considerable period of time it would appear as if lifting costs per bbl. of oil would range from 5 cents to 11 cents. The application of back pressure at the tubing-head under the lower bottom-hole pressures given in the table is seen to add greatly to the quantity of gas required to lift a barrel of oil.

TABLE 2

Quantity of gas required to lift one bbl. of East Texas crude oil under given conditions of bottom-hole pressure and back pressure.

Bottom-Hole Flowing Pressure Absolute	Cu. ft. in thousands required to lift one bbl. of oil							
	Back pressure on tubing head							
	14.4 lb.		40 lb.		75 lb.		132 lb.	
	Req'd	Available	Req'd	Available	Req'd	Available	Req'd	Available
1015	349	1,846	349	1,110	349	746	349	453
915	473	1,846	473	1,110	473	746	473	453
815	647	1,846	647	1,110	647	746	647	453
755	766	1,846	766	1,110	766	746	766	453
715	868	1,846	868	1,110	868	746	868	453
615	1,170	1,846	1,170	1,110	1,170	746	1,170	453

Estimates indicate that the cost of installing two small compressors of about 350,000 cu. ft. per day each driven by different kinds of power units would range from $10,000 to $18,000.

Under present conditions of pressure in the East Texas field, it is estimated that a plant consisting of two compressors could handle from 10 to 40 wells producing at the present allowable rate. The cost of this plant distributed over the group of wells handled would probably amount to an average of somewhere between $500 and $1500 per well.

Artificial Flowing of Wells. After wells are being flowed artificially, the flow can be handled continuously or intermittently by using a compressor plant to supply the extra gas required. Probably the most satisfactory arrangement would be to install a compressor plant so situated at a convenient point on high ground that high water would not interfere with the operation. Economical operation could be obtained in a plant of the proper type if the operator made certain that a study of the conditions at the wells be made so that the plant would be installed with the proper set-up.

As long as the bottom-hole pressure remains at several hundred pounds there would be in almost all cases no necessity of making any alterations of consequence at the well other than possibly to change some of the connections at the well-head. At the present time it is probable that better results would be obtained if the wells were flowed alternately, each well being produced for only a short period per day. Under these conditions the operating costs for labor and repairs should be very low. Under most conditions there would be very little work necessary to be done at the well in running tubing or for other usual well jobs.

Owing to the necessity of starting up the wells each day, whether the wells are flowed through the casing or through the tubing, the starting pressures would probably be high unless the tubing is suspended at a high point or unless starting valves are employed. While it is true that compressor installations could be made to handle any pressure that would ever be required in the East Texas field, this would be at the expense of higher installation cost for the compressor units, particularly if gas or oil engines were employed to drive the compressors.

Avoiding High Pressures in Starting Wells. The method of suspending the tubing high in the well possesses

the disadvantage that it would be necessary to produce the well for a longer period each day to obtain the desired production and would require a larger quantity of gas per bbl. of oil lifted. The tubing can be suspended low in the well by using starting valves, of which there are several makes on the market. Among the best known starting valves are the Boynton, Bryan, P. & T., and Taylor devices.

TABLE 3

Cu. ft. of gas from compressor plant required to be admitted to lift one bbl. of East Texas oil under given conditions of pressure.

Bottom-hole Pressure, Absolute	Cu. ft. of gas required per bbl.					
	Back pressure in lb. per sq. in. absolute held on the well-head					
	14.4	40	45	55	65	75
1015	0	0	0	0	0	0
915	0	0	0	0	0	0
815	0	0	0	0	0	0
715	0	0	0	0	10	25
615	0	15	30	50	80	100
515	0	90	110	150	180	210
415	75	250	280	340	390	450
315	270	565	620	720	830	940
215	690	1290	1420	1665	1935	2240
115	2400	5000	5700	7400	9200	12900

When the oil is lifted through the tubing, the compressed gas is introduced into the casing and the oil that stands in the casing is displaced into the tubing. If the tubing is suspended low in the hole, the area in the annular space between the casing and tubing compared with the area of the tubing is such that a lowering of the oil in the casing would in many cases fill the tubing to the well-head before the gas reached the bottom of the tubing. In the extreme case of a 3600-ft. well with the tubing suspended at 3600 ft., and with oil of 41-deg. A.P.I. gravity the pressure required would be approximately 1117 lb. for the gas to reach the lower end of the tubing, if no starting valves were employed.

By inserting starting valves at certain intervals, such that if the pressure of the column of oil in the tubing exceeded the pressure in the casing by a predetermined amount these valves would open, it is possible to flow off successively a part of the column of oil in the tubing. Thus if the pressure available at the well-head were 300 to 350 lb. these valves could be installed at intervals of 500 to 800 ft., thereby insuring that the well would be made to flow by the automatic admission of gas or air through the valves into the tubing in successive order until the gas had finally reached the lower end of the tubing.

Another method has been in successful use for starting wells in which the weight of the fluid column sets up a pressure greater than the pressure capacity of the compressor. This method consists in injecting gas under pressure with oil into the casing or tubing, and continuing this injection of mixed gas and oil until the gas has reached the bottom of the tubing when it will begin to return through the flow string and lighten the column, after whih the pumping of oil is discontinued and only gas under the pressure available is injected. This system is similar in principle to that employed in hydraulic compression operation which is used in a few places. [2, 3] This method possesses some disadvantages in connecting up an oil pump and might be too troublesome to use each day or several times each day, but would be much less expensive than purchasing high-pressure compressors merely to start a well only occasionally. The method has been employed in the Seminole field to good advantage, and in several instances is known to have started a well in which the bottom-hole pressure was about 1500 lb. by the use of gas from a compressor under pressure of 350 lb. This method has also been employed in a few instances in the Oklahoma City field where it is possible to have very high starting pressures.

Tubing Diameters. The choice of tubing diameter would depend on the work to be done. Owing to the fact that certain sizes of tubing have already been installed, consisting for the most part of 2-in. or 2½-in., it would be desirable on the part of economy to use tubing strings of these diameters. Probably the tubing of 2½-in. diameter would be a better choice than tubing of 2-in. diameter if new tubing were to be purchased. The smaller strings of tapered tubing that have been used in this field would probably not be found very satisfactory for the purpose of flowing with air or gas lift, especially after the pressures have declined to a low point.

Intermittent Flow. At the present time nearly all the wells flowing naturally in the East Texas field are produced on intermittent flow, that is, they are produced for a sufficient length of time each day to make the allowable and then closed down until the following day. The opening and closing of the valves is done manually in most instances, although several wells are equipped with intermitters so adjusted by clock work that they will open each day and produce the allowable and then close again.

Intermittent gas-lift flow can be handled with or without a chamber attached to the tubing at the bottom of the well. With high pressures and, therefore, with high fluid levels, there would be no need of using the chamber in the well; the accumulated contents could be discharged periodically in much the same way that wells are flowed naturally except that compressed air or gas would be admitted to the well each time it is desired to make a flow. For this purpose the valves could be manipulated by hand or by means of automatic intermitters. If a pressure of 350 lb. were available this would balance a column of approximately 1000 ft. of East Texas oil. In a casing of 6⅝-in. diameter the contents of 1000 ft. would be almost 35 bbl., which would mean that the total allowable for the day in many cases would be discharged in one flow. By raising the tubing the starting pressure could be lowered; but if starting valves were employed the tubing could be lowered to the bottom of the well.

After the bottom-hole flowing pressure had declined to a much lower point, it would be more economical in the use of compressed gas to change the tubing arrangements by placing a chamber of the proper size on the bottom joint of 2½-in. tubing and provide the chamber at the lower end with a standing valve. A smaller tubing would then be run inside the 2½-in. tubing and the flow of oil would be discharged through the inner tubing. The gas required would be intermittently admitted to the space between the 2½-in. and the smaller size tubing.

If at any time it should be desired to increase the production of oil while on intermittent flow, it would be necessary only to speed up the interval or to continue the production throughout a greater portion of the day. If a still greater production were desired than speeding up would accomplish, and assuming that the well were capable of making an increased rate, it would be possible to admit the gas continuously and bypass the intermitter. There would probably be very little if any change necessary in the hook-up at the well or in the compressor plant in carrying out changes in these rates of flow.

[2] C. H. Taylor. "Cobalt Hydraulic Air Compressor." Mines and Minerals, April, 1910.

[3] A. E. Chodzo. "Hydraulic Air Compressor." Mining and Scientific Press, December 16, 1916.

Film Coefficients of Heat Transfer

Article II

By WAYNE C. EDMISTER

Research Engineer

THE accompanying chart (pages 34 and 35) was designed to give, graphically, the values of the film coefficient and the friction factor for conditions of heat transfer and fluid flow in its range. The chart was made, using the results of Figs. 1 and 2 (published in Article I, September, 1933, issue) as well as already accepted fluid friction data.

Values of the specific heat, C; the thermal conductivity, k; the viscosity, Zi, all taken at the mean body temperature of the fluid, must be known before the chart may be used to find the film coefficient, h.

To solve a problem by means of the chart it is first necessary to find the M.T.D. (mean temperature difference) and the value for θH for heating or θC for cooling from the lower left-hand section of the chart, where:

$$\theta H = (1 - 0.0032\ (H/h)\ \Delta T)$$

in equation (7a) and where:

$$\theta C = (1 + 0.0074\ (H/h)\ \Delta T)$$

in equation (7b). To do this one must know the L.T.T.D. (least terminal temperature difference), the G.T.T.D. (greatest terminal temperature difference), and assume a value for the ratio, H/h.

The next step in the solution is to find the value of Reynolds number for the given condition of flow. This is done on the middle third of the chart by multiplying the isothermal flow viscosity, Zi, by θH or θC, and finding the flow viscosity, Zi, then evaluating Reynolds number by the multiplications indicated by the D, V, and S factor lines.

The top third of the chart represents the results of Fig. 2 combined with the graphic solution of $(hD/k)/(CZ/k)^{0.4}$ for h. Knowing h, the film coefficient; H, the overall coefficient may be found if the resistances of the tube wall and the other film are known. With H and h the original assumption of H/h may be checked. With a new value for H/h the above solution is repeated and H/h calculated as a check against the starting value. When the solution gives a value of H/h that checks the value used to start the solution, the value of h thus obtained may be considered as the film coefficient.

Using the value of Reynolds number from the corrected film coefficient solution, the friction factor and elbow friction may be determined from the lower right-hand section of the chart.

An example will illustrate the use of the chart. Oil is to be cooled in tubes with an inside diameter of 1 in. and an outside diameter of 1.25 in. from 305 to 115 deg. fahr. by water flowing outside the tubes counter currently, entering at 80 deg. fahr. and leaving at 170 degrees. The gravity of the oil, S = 0.89 and the mean velocity, V, is to be five ft. per second.

The oil has a mean main body temperature of $(305 + 115)/2 = 210$°F. At this temperature the oil has a viscosity, $Zi = 3$ centipoises; a specific heat, C = 0.8; and a thermal conductivity, k = 0.9 B.t.u./hr./sq. ft./°F./in. The thermal conductivity of the tube wall is 420 B.t.u./hr./sq. ft./°F./in., and the film coefficient of the water film on the outside of the tubes is 380 B.t.u./hr./sq. ft./°F. based on the inner surface area of the tube. Find the film coefficient, the mean temperature difference, and the friction factors from the chart.

L.T.T.D. = 115 — 80 = 35°F.
G.T.T.D. = 305 — 170 = 135°F.

With an assumed value of H/h a trial solution is made and the resulting film coefficient is used to calculate H from equation (2a). The original assumption is compared with this calculated ratio. It is evident from the result that the ratio H/h is approximately 0.70. Now enter the lower left-hand section of the chart with G.T.T.D. equal 135° F. and go to L.T.T.D.=350° F. line. At this point read the M.T.D.=740° F. and go to the left to H/h = 0.70 line, turn, go up to the cooling line and read $\theta C = 1.395$. Go to the θ scale on the viscosity chart and on the $\theta c = 1.395$ line turn at $Zi = 3$, go to the corrected viscosity scale and read Z = 4.17.

Follow the Z = 4.17 line to D = 1 in. factor line, then turn and go to the V = 5 ft. per sec. factor line, turn again and go to the S=0.89 factor line and read the value of Reynolds number on either the top or bottom scale as being 8300. Go along the 8300 Reynolds number line into the top part of the chart to where it is crossed by the turbulent flow line. The value of $(hD/k)/CZ/k)^{0.4}$ is here found to be 109. Turn on this line and go to the left to the C = 0.8 factor line. At this point turn again, go downward to k = 0.9 factor line, then turn and go to the left to Z = 4.17 factor line, turn again and go to D = 1 in. factor line. At this point turn to the left and go to the h scale where h is found to be 188.

In equation (2a), with $h_2 = 380$, $h_1 = 188$, $r_1 = 0.50$, $kt = 420$, and $r_2 = 0.625$, H_1 is found to be 130 B.t.u/hr./sq. ft./°F. The ratio is H/h = 130/188 = .691, which checks the starting value of 0.70.

Equation (12) may now be used to find the relation between total heat flowing and the inside surface area of the tube, A_1:

$$Q/\theta = A_1 H_1\ T = A_1 \times 130 \times 74 = 9610\ A_1,$$

which means that one sq. ft. will handle 9610 B.t.u. per hr. under the above conditions.

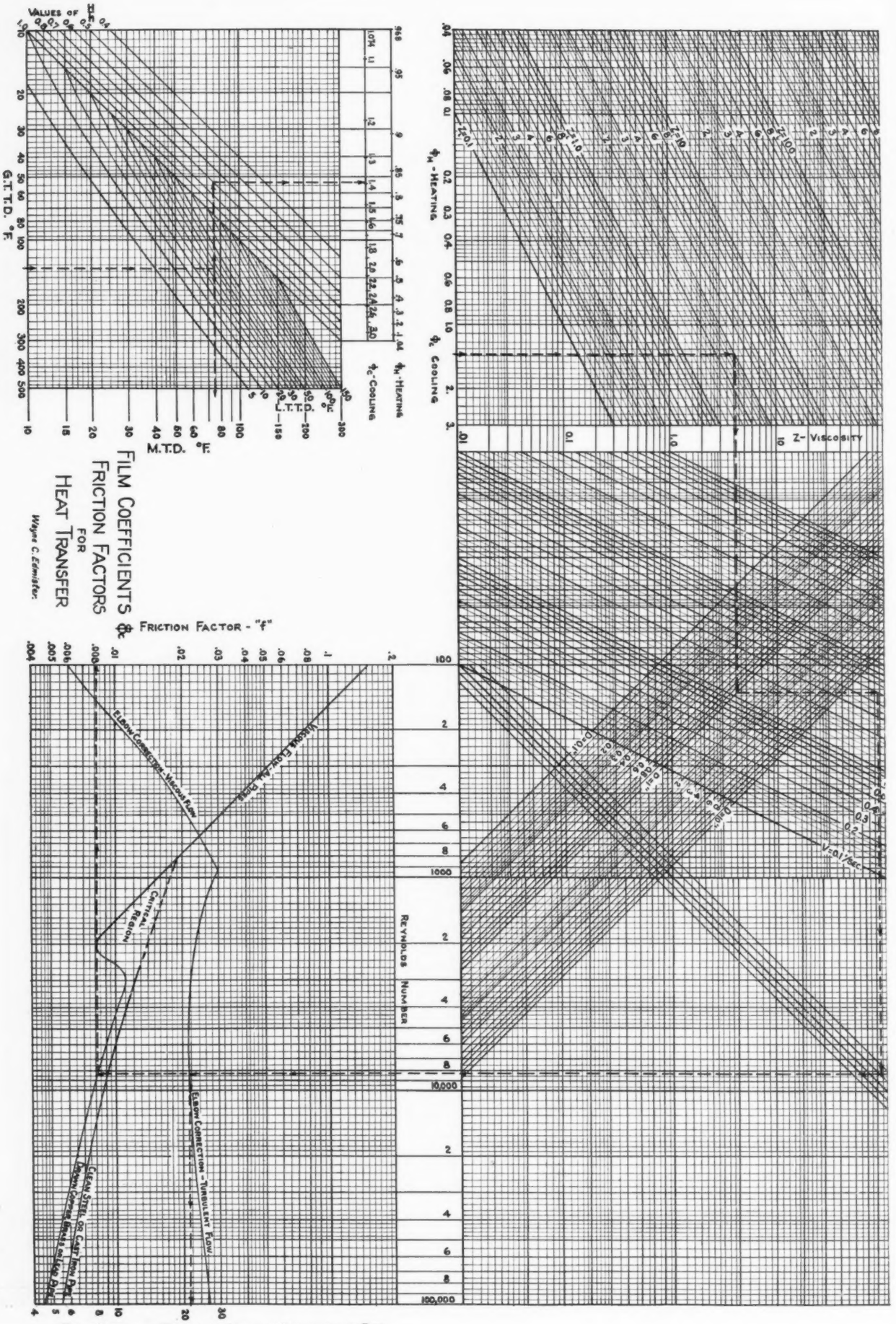
To determine the friction drop, go along the 8300 Reynolds number line to the elbow-friction curve and friction-factor curve. These operations give an elbow friction of 21.5 equivalent lengths in diameters and a friction factor, f = .0082.

The pressure drop may now be calculated, using the Fanning formula:

$$\Delta P = (0.333 \times f \times CLV^2)/D$$

in which: ΔP = pressure drop in lb. per sq. inch
L = length of tube in feet
f = friction factor, and
D, V, and S are the same as aforementioned.

It is believed that the accuracy of this chart (shown on the two following pages) is high enough for engineering calculations. In using it, however, the engineer must bear in mind the fact that it is based on data from laboratory experiments and that in applying the results to actual operating conditions the proper allowances must be made for conditions of the tubes, etc.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FRICTION FACTORS
FOR
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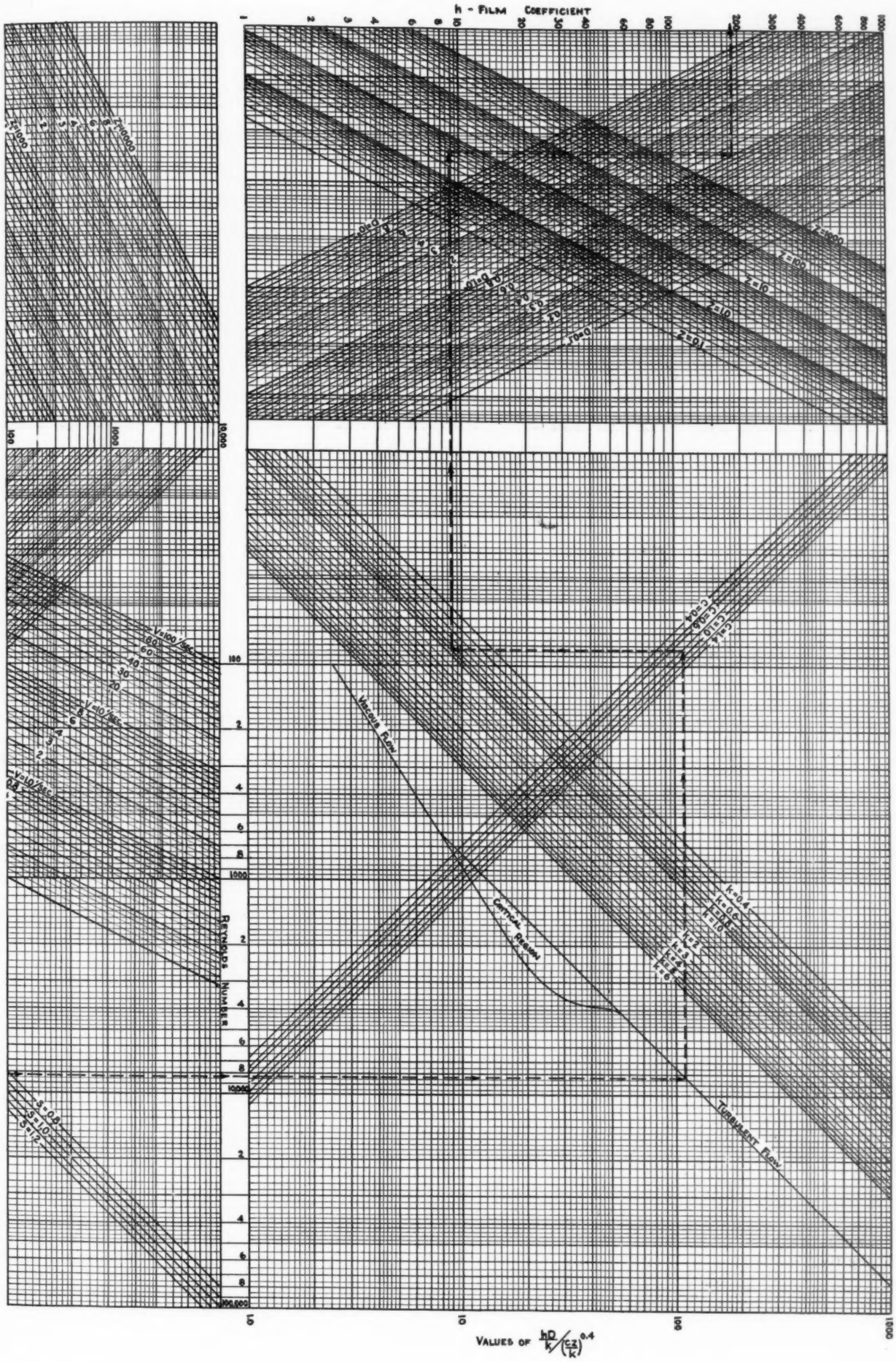
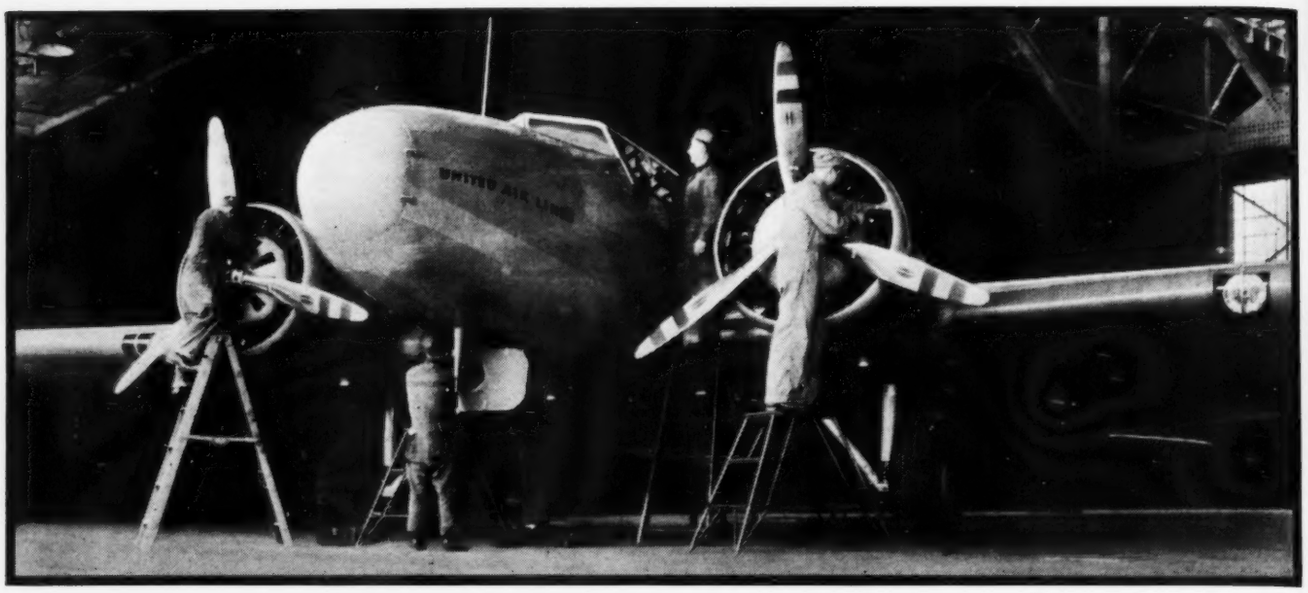
Wayne C. Edmister.
M.T.D. °F.
G.T.T.D. °F.
L.T.T.D.
Φc - Cooling
Φh - Heating
Z - Viscosity
Friction Factor - "f"
Reynolds Number
Elbow Friction in Equivalent Length in Diameters of Pipe
Elbow Correction - Turbulent Flow
Critical Region
Clean Steel or Cast Iron Pipe
Elbow Connection - Viscous Flow
Viscous Layer - All Pipes
V=0.1 ft/sec


h - Film Coefficient
Reynolds Numbers
Viscous Flow
Critical Region
Turbulent Flow
Values of $\frac{hD}{k}\left/\left(\frac{cz}{k}\right)^{0.4}\right.$



Mechanics giving one of the 4¾ hours Chicago-New York planes an overhaul

Changing Engine Designs Stress Importance Of Proper Aviation Fuel

By R. E. JOHNSON
United Air Lines

THE present day efficiency of airplane operation, illustrated by the fact that one company, United Air Lines, last month flew 98 per cent of 1,250,000 miles scheduled with three-mile-a-minute multi-motored transports, is due not only to the progress made in airplane design and construction, and improved operating practices, but to the co-operation of the technical men of the oil companies who have steadily improved their products. They have developed a superior type of gasoline and a grade of lubricating oil and rocker arm grease such as is required for high-compression airplane motors.

As the airplane manufacturers in recent years have streamlined their product to a point where great increases in speed must now come from improved power plants, the importance of proper fuel is readily appreciated. Maximum anti-knock properties are essential in standard aviation gasoline, and fuels of the highest quality are insisted upon by air line operators; likewise, lubricating oils must be of absolutely top quality if engine maintenance efficiency is to be expected in air transportation. As aviation has demanded more and more of the petroleum industry in the way of fuels during the past, so is it likely to continue these demands in the future; for it is apparent that the trend in airplane development is toward aviation power plants of increased horsepower, the gain in horsepower rating being achieved through supercharging and increasing the compression of engines.

With the use of consistently higher compression engines in air transport operations in the United States, the problem of supplying air-line operators with proper gasoline and lubricating oils has constantly confronted the petroleum industry. Each new airplane that has made its debut on the airways of the United States has been equipped with a power plant of higher compression than its predecessor. An instance of this is found in the placing in service by United Air Lines a fleet of 60 three-mile-a-minute Boeing passenger-cargo monoplanes on the company's New York-Chicago-Pacific Coast, Chicago-Kansas City-Texas, and Seattle-San Diego airways. These 1933 model planes are powered with model S-1-D-1 Wasp engines, supercharged to deliver 550 hp. at 5000 ft. above sea level.

Prior to the acquisition of these aircraft, United Air Lines was operating Boeing tri-motors (three Hornets of 525 hp. each) and Ford tri-motors (three Wasps of 425 hp. each). An aviation gasoline of 73-octane rating was used for these planes, but with the placing in service of the new speed planes and the higher compression Wasps, United required gasoline of 80-octane rating to get proper performance from its aircraft power plants.

One way of emphasizing the importance of proper fuel and proper care of airplane engines is the contrast between power plants used in airplanes and those used in automobiles. United Air Lines, in flying 2700 miles from California to New York in 20 hours, including 12 stops, uses three airplanes, each of which has two 550-hp. Wasp motors. The planes carry ten passengers, two pilots, a stewardess, mail and express. To maintain such a high cruising speed, each of the two 550-hp. Wasp motors is turned over at about 2000 r.p.m., and is operated at 75 to 80 per cent of its capacity. The average automobile engine is operated at only 25 to 35 per cent capacity; furthermore, it is not so fine a piece of machinery as the airplane motor, which weighs only 1¼ lb. for each rated horsepower. Many automobile engines weigh 15 to 20 lb. per horsepower. These Wasp engines on United's

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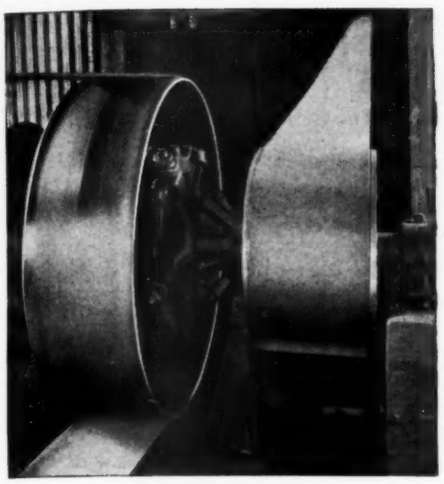

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The summer of 1933 marked the greatest increase in speed in the history of air transportation. From 1925 to 1927, typical cruising speed of commercial airplanes was around 100 miles per hour; by 1932 this had increased to approximately 115 miles per hour; this summer there are in service multi-motored passenger transports capable of cruising speeds as high as 171 miles per hour. It has been demonstrated that each time there has been a speeding up of air travel, traffic has increased, and the average ride has been lengthened. Likewise, speedier planes have brought an increase in night flying, which affords a maximum of time-saving, when measured in terms of business hours. Therefore, the airplane companies and operators have been concentrating on speedier equipment.

The speed of transport planes depends chiefly on the type of design and the construction, the efficiency of the power plant, and the degree to which comfort features, which add weight to the plane and influence its design, are considered. The public, while it wants speed and more speed, is not satisfied with riding in cramped space or without comfort features. In the new Boeing high-speed, multi-motored transports, the engineers allowed 170 lb. for each passenger, and then added 107 lb. for comfort feature allowance per passenger.

Extra speed itself means added economy; for planes are flown considerably farther per hour of flying time. When operations were first started on the San Francisco-New York route, seven single-engined mail planes were used in the 2776-mile flight. Today United Air Lines uses only three of the high-speed multi-motored planes on a 20-hour Coast-to-Coast flight.

Fuel consumption is an important item in airplane operation, and the medium-sized twin-motor transports effect economies over the tri-motored equipment. For instance, the new Boeing twin-Wasp ten-passenger-cargo planes consume 360 gal. of gas and 24 qt. of oil per 1000 miles cruising, as against 675 gal. of gas and 55 qt. of oil in a Ford tri-motor (three Wasps), and 810 gal. of gasoline and 90 qt. of oil for the Boeing tri-motor (three Hornets). The latter plane had to have great horsepower for its biplane type of construction and because of the heavy loads and high altitudes on the Coast-to-Coast route.

Because leading companies in the petroleum industry have been devoting research efforts to improve aviation fuels since the early days of air transportation, the useful life of an aircraft engine has been materially prolonged. There has been, of course, definite improvement in construction of aircraft power plants, with superior materials and more expert engineering work contributing to more efficient products. However, it is conceded that increasingly higher standards in aviation fuels have played a very important part in increasing the efficiency and adding to the life of transport plane engines.

As examples of the improved conditions in aviation engines, during the early days, 1927 and 1928, when private companies were entering the field of air-mail transportation, it was the practice on leading air lines to make a complete overhaul of aircraft engines every 200 hours; and the airplane engines were deemed to have out-lived their usefulness at approximately 1500 hours. Today, it is the practice on air lines to pull engines from planes for major overhauls at intervals of 300 to 350 hours of flying service, and aviation engines that have been operated 2000 hours at 75 per cent capacity are still regarded as efficient and good for further service.

Famous English Flyers Entertained By Shell Aviators

This famous foursome holds a score of flying honors: Left to right are Captain James G. Haizlip, Mrs. Amy Mollison, Capt. James A. Mollison and Mrs. May Haizlip. In the Shell plane is Major R. G. Ervin.

FOLLOWING their sensational Shell-fueled flight across the Atlantic, Captain James A. Mollison and Mrs. Amy Mollison, England's famous long-distance flyers, were entertained in New York by Captain James G. Haizlip, holder until a few days ago of the American transcontinental speed record and who is flying assistant to Major James H. Doolittle, manager of Shell Petroleum Corporation's Aviation Department, and Mrs. May Haizlip, holder of the women's record for land-speed planes.

These famous flying couples are shown in the photograph, with Major R. G. Ervin, manager, Aviation Department, Shell Eastern Petroleum Products, Inc., just before taking off from Floyd Bennett Field at Brooklyn for Bridgeport Airport in the Shell tri-motored Ford plane.

Solving Well-Pumping Equipment Problems

ARTICLE VII—GEARS

By HYMAN LEEDEN
Engineer-in-Charge, Western Division,
The Falk Corporation, Milwaukee, Wis.

NOISE AND VIBRATION

A PAIR of gears is essentially a "loose-coupled" device. It is possible to push the gears together until they are "tight" in mesh. but it isn't done, except by the uninitiated, for obvious reasons.

A normal condition for herringbone or spur gears is: The driving side of the pinion tooth is in contact (at times) with the driven side of the gear tooth. There is space for clearance on the other side, which may be anything from ten thousandths to a sixteenth in new gears. Wear, of course, increases the clearance. Clearance is *necessary* to provide room for expansion with changes of temperature and to permit proper lubrication. Clearance is also desirable from other considerations, as will appear.

In almost all cases noise is caused by recurrent separation and return of contact between the teeth of the pinion and the teeth of the gear. Separation can take place only when there is a variation in the instantaneous values of relative angular velocity as compared with the mean values established by the velocity ratio (numbers of teeth) and the revolutions per minute of the pinion. The causes for tooth separation are frequently, but not necessarily, due to imperfections in the gears themselves. They may be due to outside conditions that have little or nothing to do with accuracy or gear cutting. This is a point that should be better understood by gear users to whom a noisy gear is usually a bad gear.

It may be generally said that a pair of herringbone (double helical) gears will be inherently quiet in operation *except* for adverse *external conditions*, provided that

1. The division of the teeth is accurate and concentric with the axes.
2. The shafts are true and round.
3. Revolving parts are in correct running balance.

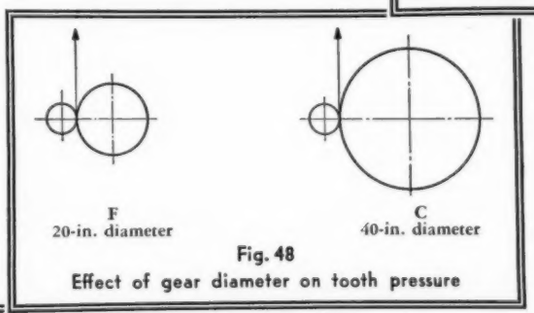


Fig. 48
Effect of gear diameter on tooth pressure

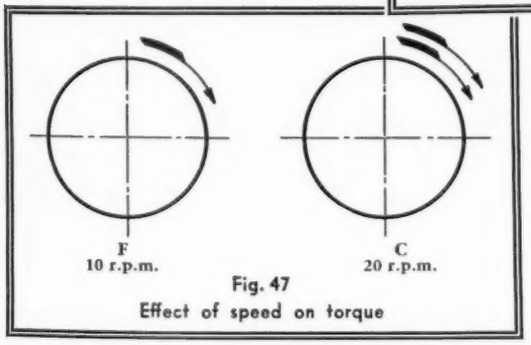


Fig. 47
Effect of speed on torque

4. Shaft centers are correct and allow proper running clearance for the teeth.
5. Shafts are parallel to each other.
6. Spiral angles are correct and equal.
7. No point on the working surface of any tooth lies outside of the involute curve through the pitch point (see Fig. 44). This is most important.
8. The teeth are properly lubricated.

Noise and Vibration from External Causes. There are several types of machinery that, in themselves, create conditions making for noise, vibration and undue wear and tear.

The average oil well gives a fair illustration of the class of machinery referred to. The sucker rod and plunger move upward and downward; the crank revolves and the beam oscillates. The speed of the plunger and rods is not constant. It varies from zero to maximum and from maximum to zero. The rate of change of speed also varies with different conditions in the well—gas, water encroachment and volume, and with conditions outside the well, such as counterbalances, looseness of pins and bearings, and construction of crank. There is also the condition of misalignment between the crank and the pitman, or between the beam and the gear unit. With such a variety of conditions, uniform angular velocity of gear and pinion is physically impossible. There is bound to be a certain amount of separation of teeth at the points of contact, and this separation will cause more or less noise some time during the life of the well. To a certain extent, this noise can be reduced temporarily within the gear itself, by reducing the running clearance (backlash) or by using a very heavy lubricant between the gear teeth. Such expedients, it must be recognized, are temporary in nature only, and do not remove the causes of the noise.

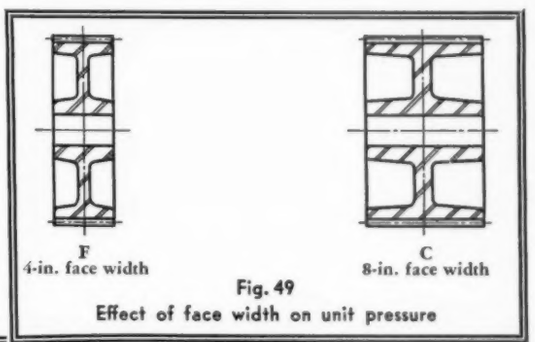


Fig. 49
Effect of face width on unit pressure

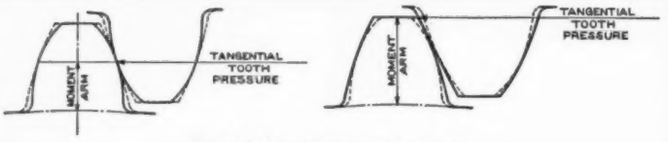
If the amount of counterbalance is insufficient, so that the rods run away from the motor, or if the pumping speed is so high that the pump "pounds fluid" or if the beam is badly misaligned with respect to the gear unit, noise is bound to result that will be called gear noise, but which in reality will be bad pumping conditions. To reduce this noise, it is necessary to balance the well properly, to select carefully the operating speed, to make sure that all parts are in alignment, that all bearings are properly lubricated, and that there is no excessive looseness anywhere in the mechanism. When these things have been done, gears will be found to be quiet—as quiet as it is possible to make gears for the varying load conditions of oil field service.

The reduction in noise, due to long-stroke, slow-speed operation is not a reduction due to the difference of pitch

line velocity of the gear, but is principally a reduction due to the smoother flow of power and to improved pumping conditions.

Factors Affecting Life and Load-Carrying Capacity of Gears

When considering the purchase of gear units, engineers are sometimes tempted to compare the physical dimensions—pitch, face width, diameter, centers, etc.—of two units, and to reason that the unit with the larger dimensions has the larger horsepower capacity. Such reasoning appears logical, and is actually valid, when the comparison is made of two like things. However, such reasoning may fail, and may lead to entirely erroneous conclusions when comparing the herringbone gear unit of one manufacturer with the herringbone gear unit of another manufacturer. The larger unit may actually have the smaller capacity.

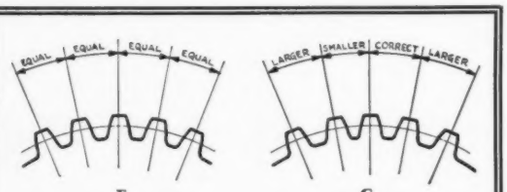


Dotted lines show true involute.
Solid lines show actual tooth, differences exaggerated.

F—Gear with tooth contour *inside* of involute. See Fig. 44.

C—Gear with tooth contour *outside* of involute. See Fig. 45.

Fig. 50
Effect of tooth inaccuracy on tooth bending stress



F
Accurately divided

C
Inaccurately divided

Fig. 51
Effect of tooth spacing on tooth stresses

Let us take a little journey through the inside of a gear unit and observe a few of the items that affect load-carrying capacity. Some of these are well known and may be found in text books; others are not so well known to the public, but have been determined by years of experience in the gear makers' art. Let us start with the main member, the gear itself, exaggerating differences for the sake of emphasis and clarity.

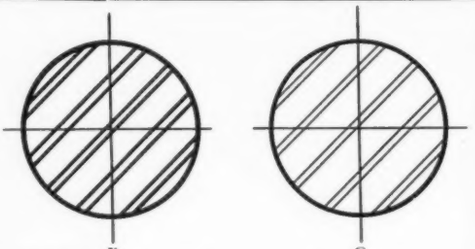
Speed and Torque: Fig. 47 shows two gears, carrying the same horsepower each, but one, gear F, revolving at 10 r.p.m., and the other, gear C, revolving at 20 r.p.m. The torque transmitted, and therefore the various stresses produced, are twice as great on gear F as on gear C.

Gear Diameter and Tooth Pressure: Fig. 48 shows two trains of gears, carrying the same torque each, but one, gear F, is 20-in. diameter, and the other, gear C, is 40-in. diameter. The tangential tooth pressures, and the various stresses produced, are twice as great on gear F as on gear C.

Face Width and Unit Pressure: Fig. 49 shows two gears, carrying the same tangential tooth pressure each, but one, gear F, has a face width of 4 in., and the other, gear C, has a face width of 8 in. The pressure per inch of face, and the various stresses produced, are twice as great on gear F as on gear C.

Tooth Inaccuracy and Bending Stress: Fig. 50 shows the teeth of two sets of gears in engagement, each carrying the same unit tooth pressure per inch of face per inch of tooth thickness, but due to the nature of the tooth form inaccuracies, the pressure on F is concentrated at the pitch line, while the pressure on C is concentrated at the tip of the tooth (at some point in its contact cycle). The bending stress at the root of the tooth, tending to produce breakage, is twice as large on gear C as on gear F. Gear F has twice the load-carrying capacity of gear C.

Tooth Spacing and Tooth Stresses: Fig. 51 shows two gears, each with the gear tooth contact at the *inside* of the involute, each carrying the same pressure per inch of face per inch of tooth thickness, concentrated at the pitch line. But gear F is cut on a generating machine with compensated division, giving only minute errors of tooth spacing (see Fig. 12), while gear C is cut on some other machine not nearly so accurate, giving some tooth spaces larger and some smaller than average. These inaccuracies produce impacts at engagement, the effect of the impacts being an increase in the tooth stress otherwise existing, and the magnitude of the impacts depending on the amount of the inaccuracy. On the gear F, with its accurate tooth spacing, the impacts are light (at that, they will be enough to double the normal stress at a pitch line velocity of 6,000 ft. per minute). On gear C, however, due to the larger inaccuracies, the impacts are heavier (varying probably as the square of the inaccuracies), and the actual stresses in gear C will be higher than the actual stresses in gear F. Though the theoretical stresses computed by usual methods may appear to be the same, gear F has more actual load-carrying capacity than gear C.

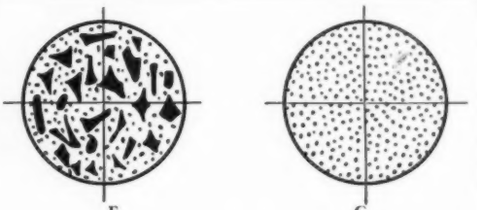


F
Alloy steel heat-treated

C
Carbon steel

Fig. 52
Effect of material on tooth strength

Material and Tooth Strength: Fig. 52 shows two gears, made of different materials, but otherwise identical. Gear F is made of a high-grade chrome-nickel molybdenum steel, having an elastic limit of 100,000 lb. per sq. inch. Gear C is made of .40 to .50 carbon steel and has an elastic limit of 50,000 lb. per sq. inch. Gear F is capable of carrying twice as much load as gear C.



F
Alloy steel
Heat-treated uniformly

C
Alloy steel
Improperly heat-treated

Fig. 53
Effect of heat treatment on tooth capacity

Heat Treatment and Tooth Capacity: Fig. 53 shows two gears, otherwise identical, both of heat-treated alloy steel. But gear F has been heat-treated slowly and uniformly; gear C has been treated rapidly and non-uniformly. While both show on test an elastic limit of 100,000 lb. per sq. in., it must be remembered that such a figure represents only a

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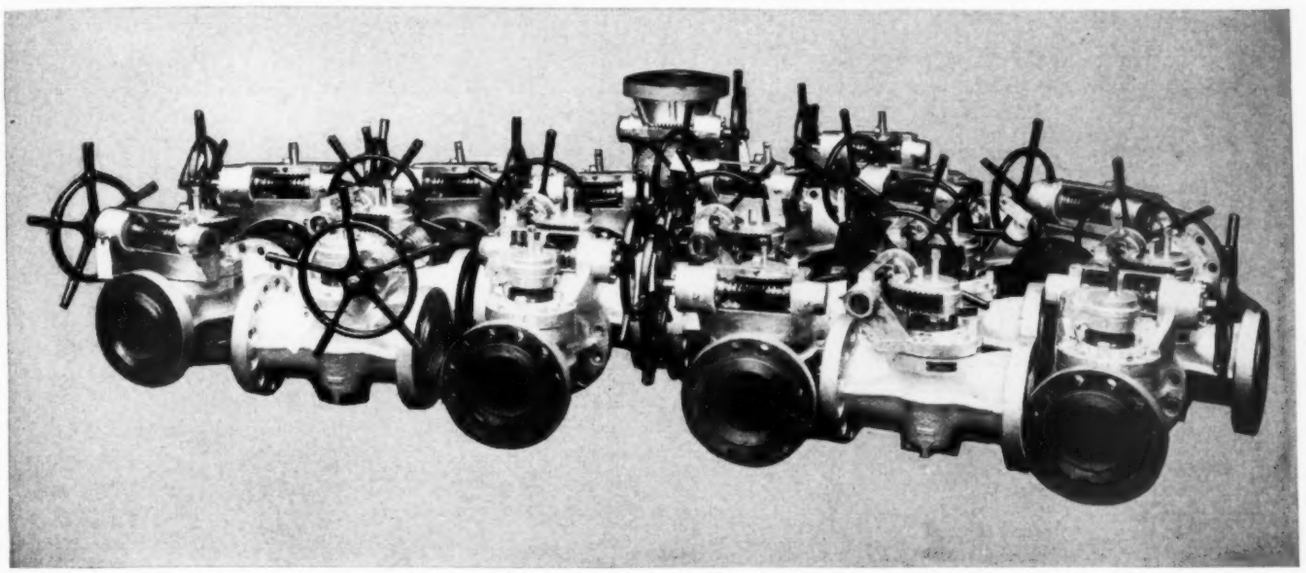

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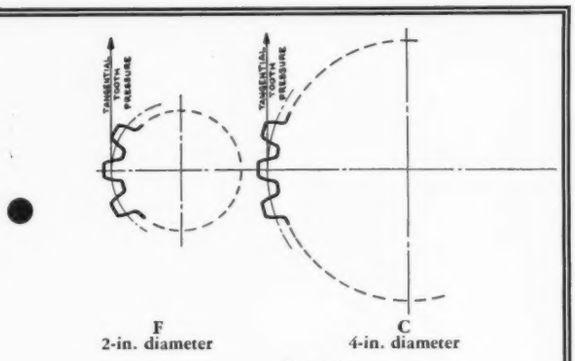

Fig. 54
Effect of pinion diameter on tooth wear

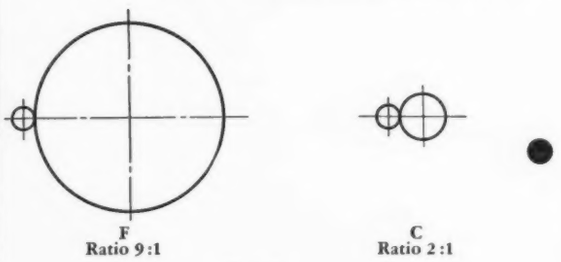

Fig. 55
Effect of gear ratio on tooth wear

statistical average for the gear as a whole; the actual strength from particle to particle will vary above and below the average. In gear F the variations are small; the strongest particle will be, let us say, 120,000 lb. per sq. in., the weakest 80,000 lb. per sq. inch. In gear C, however, the variations are large; the strongest particle will be, let us say, 150,000 lb. per sq. in. and the weakest 50,000 lb. per sq. inch.

The normal tooth stresses, added to the impacts, will attack both gears and seek to destroy them by fatigue—another name for progressive rupture. They will find a much easier opening in gear C, where the weakest particle is 50,000 lb. per sq. in., than in gear F, where the weakest particle is 80,000 lb. per sq. inch. As one weak particle after another is destroyed, the effective remaining area is reduced, the stress per remaining square inch under the same load is increased, and the stronger particles begin to break, until the whole structure must give away.

In the struggle against fatigue, gear F has a greater load-carrying capacity than gear C.

In gears we are interested not alone in strength, but also and principally in wear.

The *strength* of a gear tooth is a function of the *pressure per inch of face per inch of tooth thickness* (K = P/Ft) modified (as has been shown) by frequently forgotten but nevertheless important factors. The *wear* of a gear tooth is a function of the *pressure per inch of face per inch of diameter* (Q = P/Fd) modified (as will be shown) by similar factors.

Pinion Diameter and Tooth Wear: Fig. 54 shows two gears, each having the same pressure per inch of face per inch of tooth thickness, and each of equal tooth strength. But one, gear F, is 2 in. in diameter, and the other, gear C, is 4 in. in diameter. The loads tending to produce breakage are the same, but the loads tending to produce wear will be twice as heavy on gear F as on gear C, and the greater life will be with gear C, unless modified by other elements.

Gear Ratio and Tooth Wear: Fig. 55 shows two trains of gears, each with the same apparent wear load per inch of face per inch of diameter. But one, gear F, has a ratio of 9:1, and the other, gear C, has a ratio of 2:1. This difference in ratio makes a definite and mathematically demonstratable difference in the actual wear loads on the two gears; the greater stress is on gear C, and the lesser on gear F. The actual wear load on gear C is 1.500 times the apparent; the actual wear load on gear F is only 1.111 times the apparent. Gear F has 36 per cent more actual capacity than gear C.

Tooth Deflection and Tooth Wear: Fig. 56 shows two gears, each having the same ratio, and same apparent wear load in pounds per inch of face per inch of decimeter. But one, gear F, is relatively large in diameter and narrow in face; the other, gear C, is relatively smaller in diameter and wider in face. Gear F is so stiff, as a beam, that there is relatively little deflection under the load; the stresses distribute themselves as computed—equally over the whole face width. But gear C is not so stiff as a beam; there is more—much more—deflection under the load (for deflection varies directly as the cube of span and inversely as the fourth power of the diameter); the stresses do not distribute themselves as uniformly over the face width of the gear teeth as the merely arithmetical figures would mislead one into believing; the stresses are heavy at the ends and keep reducing towards the middle of the face width. Given the same total tangential pressure, the actual tooth stresses at the point of contact will be heavier on gear C than on gear F, though they compute alike. Gear F has more actual load-carrying capacity than gear C.

Pitch-line Velocity and Tooth Wear: Fig. 57 shows two gears, each of equal accuracy, and apparently equally loaded in pounds per inch of face per inch of diameter; each is held within safe deflection limits. But one, gear F, is revolving at a pitch line velocity of 2,000 ft. per min., and the other, gear C, is revolving at double the pitch-line velocity, or 4,000 ft. per min. The impacts produced by velocity alone increase the apparently equal tooth stresses by unequal amounts. The stresses in gear F are increased by 57 per cent over their static values, while the stresses in gear C are increased 81 per cent over their static values; consequently gear F has 15 per cent more load-carrying capacity than gear C.

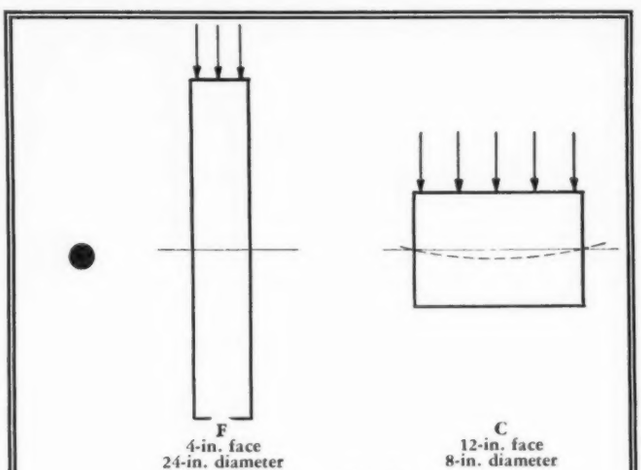

Fig. 56
Effect of tooth deflection on tooth wear

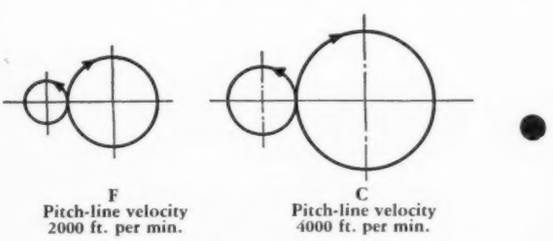

Fig. 57
Effect of pitch-line velocity on tooth wear

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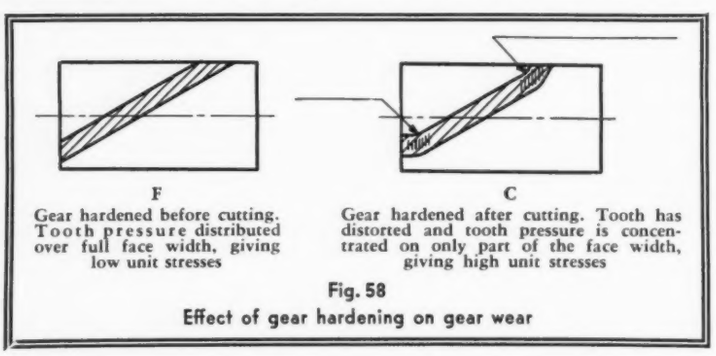
Gear Hardening and Gear Wear: Fig. 58 shows two gears alike in dimensions, materials and loading, but one, gear F, has been given its proper hardness *before* the teeth were cut; the other, gear C, was given its proper hardness *after* the teeth were cut, and the gear was then ground in. During the hardening operation, the teeth in gear C (which were already cut) have become distorted, and the pressure is concentrated on less than the full face width of the teeth; the unit stresses are therefore higher than mathematically computed, and the actual capacity is reduced below the theoretical capacity. The teeth in gear F, however, were cut before the hardening operation, the pressure is divided uniformly over the full face width, and the actual capacity is equal to the theoretical capacity. Gear F will carry more load than gear C.

Tooth Spacing, Materials, Heat-Treatment, and Gear Life: Figs. 51 (accuracy of division), 52 (materials) and 53 (heat treatment) affect the *wear life* of gears as well as their strength. Gears F, which are accurately generated, made of good material, and properly heat-treated, will have more load-carrying capacity than gears C, the teeth of which are inaccurately spaced, and which are made of weaker materials, or not so well heat-treated.

Bearing Size and Gear Life: Gears do not run on intangible pivots, suspended in thin air; they must be mounted on shafts that rotate in bearings.



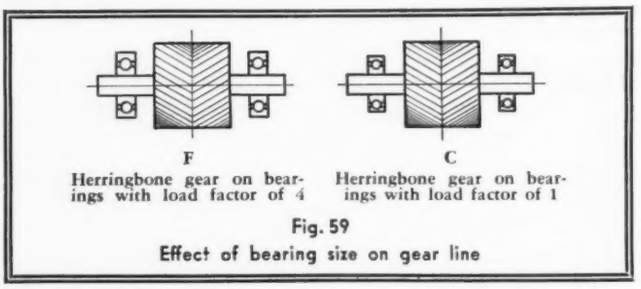
F
Gear hardened before cutting. Tooth pressure distributed over full face width, giving low unit stresses

C
Gear hardened after cutting. Tooth has distorted and tooth pressure is concentrated on only part of the face width, giving high unit stresses

Fig. 58
Effect of gear hardening on gear wear

Fig. 59 shows two herringbone gears, identical in all respects, except the bearings on which they are mounted. They are made of the same materials, cut on the same machine, loaded to the same extent, and the tooth stresses are equal. One, gear F, is mounted on a bearing whose capacity rating is four times the bearing pressure, while the other, gear C, is mounted on a bearing whose capacity rating is exactly equal to the bearing pressure. The wear life of the two bearings will determine the wear life of the gears, for no gear can continue to function after the bearing on which it is mounted has worn out.

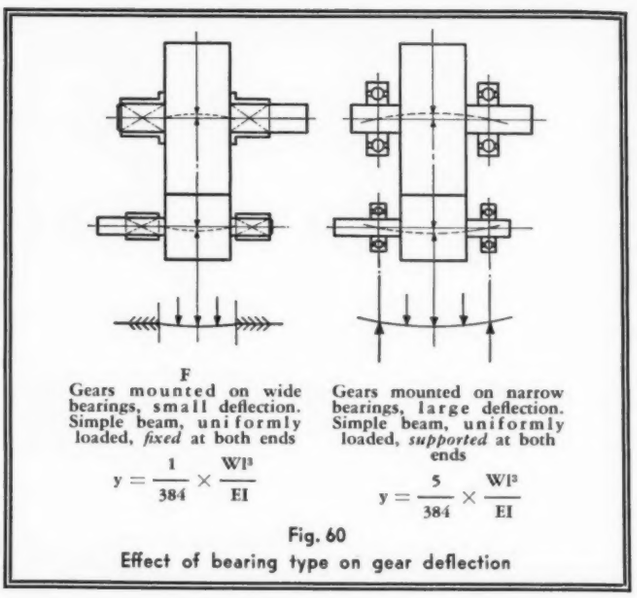
Type of Bearing and Gear Deflection: Gears, even when mounted on bearings, do not run by themselves alone; by their very nature they must run in pairs, such as two gears, or a pinion and a gear. The type of bearing selected will often determine how well the gears "run together." Fig. 60 shows two trains of gears, equal in workmanship, material, loading, etc., and mounted on bearings having more than ample capacity. But one train, C, is mounted on a narrow bearing, best typified by the ball bearing shown, while the other, F, is mounted on a real wide bearing, best typified by the airplane sleeve bearing shown. Under load, both pinion and gear will deflect away from each other, tending to put more load at each end of the gear train than at the center; the differential between the load at the end and the load at the center will depend upon the deflection that is produced; the life of the gear train will depend more on the actual stress at the ends than on the theoretically uniform stress across the whole face.



F
Herringbone gear on bearings with load factor of 4

C
Herringbone gear on bearings with load factor of 1

Fig. 59
Effect of bearing size on gear line



F
Gears mounted on wide bearings, small deflection. Simple beam, uniformly loaded, *fixed* at both ends

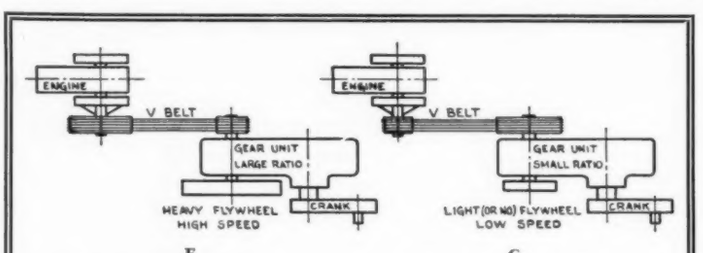
$$y = \frac{1}{384} \times \frac{Wl^3}{EI}$$

Gears mounted on narrow bearings, large deflection. Simple beam, uniformly loaded, *supported* at both ends

$$y = \frac{5}{384} \times \frac{Wl^3}{EI}$$

Fig. 60
Effect of bearing type on gear deflection

Gear F, being held rigid, in good wide bearings, will act approximately as a simple beam, fixed (in the bearings) at each end, and uniformly loaded across the face. The deflection produced will be $y=Wl^3/384EI$. Gear C, being held in narrow bearings that are almost perfectly free to pivot, will act as a simple beam *supported* (in the bearings) at each end, and uniformly loaded across the face. The deflection will be $y=5Wl^3/384EI$, or five times the deflection of F. The load differential between the ends and the center of the gear train will be higher, the *actual* stresses at the ends will be considerably higher on gear train C than on gear train F, even though the usual formula may show them to be alike. Under a sufficiently heavy loading condition, gear C will fail rapidly, while gear F will continue transmitting its loads.



F
Engine-driven gear unit protected by flywheel

C
Engine-driven gear unit not protected by flywheel

Fig. 61
Heavy and light flywheels

Flywheels and Life of Gear: The size, weight, and speed

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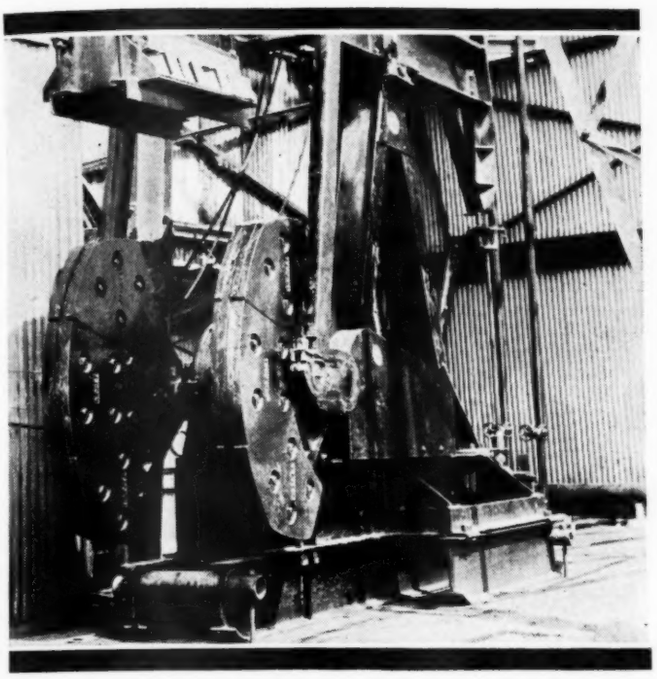

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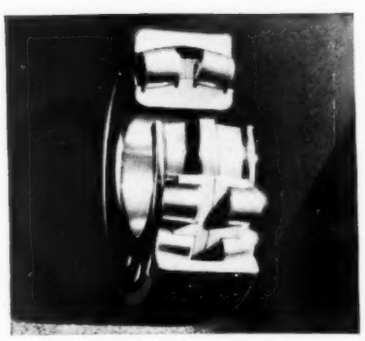

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of the flywheel will affect the life of the gear unit, especially when driven by an internal combustion engine.

Fig. 61 shows two oilwell pumping units, driven by internal combustion engine. The units are alike in construction and workmanship, except that gear unit F is equipped with a heavy flywheel, and the gear ratio is such that the flywheel revolves at relatively high speed, while gear unit C is equipped with a very light flywheel (or possibly none at all), and the gear ratio is such that the flywheel revolves at relatively slow speed. For a flywheel of the same dimensions, the effect will vary with the weight and the square of the speed: flywheel at F is therefore much more effective than flywheel at C.

In gear unit F, the shocks and impacts coming from the engine are caught and absorbed by the effective flywheel, and are prevented from doing damage to the gears and bearings. In gear unit C, however, the flywheel is either non-existent or ineffective, and all the engine impacts go right through the gears and bearings; their effect is precisely the same as an increase in load at the well. In gear unit F, the stresses on gears and bearings are the same as the ordinary computations show; but in gear unit C, the stresses on gears and bearings are much higher than the ordinary computations show. While both gear units may have the same dimensions and may pump wells of identical loads, gear unit F will have more actual capacity, and will last longer than gear unit C.

Conclusion

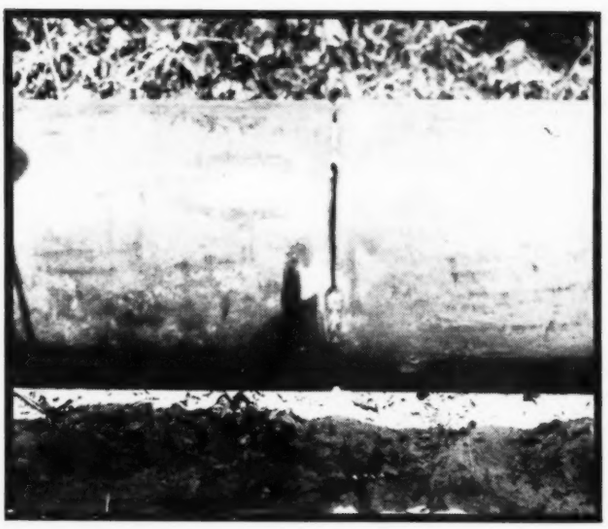
Thus we see that the life and load-carrying capacity of a gear unit depends not alone on diameter and face width, on pitch and number of teeth of gears, but on a whole host of other items that, in many cases, are equally important.

When comparing two gear units, it is not sufficient to look at a few easily-computed stresses; it is necessary also to consider such things as materials and heat treatment, tooth form and tooth spacing, tooth thickness and pitch diameter, ratio and velocity, deflection and hardness, size and type of location of bearings, balancing of loads and provision for lubrication, size and shape of housing, weight and speed of flywheel, etc. Some of these items lend themselves to mathematical computation, but others depend on the gearmaker's art, on his knowledge and experience in manipulating load transmitting elements, and securing a maximum of capacity from them.

(This concludes the series of articles by Mr. Ledeen.—*Editor.*)

First Line of Arc Welded Torch-Cut Pipe Completed

OLD pipe on a large line had never been taken up, torch cut and electric welded until recently when, on the Sinclair-Prairie Pipe Line Company's transmission system from Teague, Texas, to Huffman, Texas, just completed, the 70-mile section between Teague and Singleton was laid by this method, thus establishing the practicability of arc welding torch-cut pipe.



Pipe tacked ready for welding on Sinclair-Prairie pipe line

The pipe used in laying this line was 12¾ in. in diameter with a ⅜-in. wall, and had been in service in Oklahoma prior to being taken up, shipped to Texas and relaid. It was cut with an automatic machine, and despite the fact that the ends were not quite smooth or true, no difficulty was encountered by the welding contractor, H. C. Price, Inc., of Bartlesville, Okla., in making the arc welds. Some difficulty was experienced in lining up the pipe and making the ends fit with the proper spacing. Naturally there was no shoulder on the end of the pipe. Due to the feather edge it was necessary to space the pipe as closely as possible. In most cases this was between $\frac{1}{32}$ and $\frac{1}{16}$ inch. (See illustration.)

Although the country traversed was rough, sandy and heavily wooded, welders on the firing line made unusually good speed. As many as 34 joints were arc welded per man per day. Welding on this half of the line was done by the shielded arc process, using Fleetweld electrodes and gasoline engine driven welders manufactured by The Lincoln Electric Company, Cleveland, Ohio.

Tacking was done with ¼-in. electrodes. The first bead was run with $\frac{3}{16}$-in. or ¼-in. electrodes, depending on the spacing, the second bead with $\frac{5}{16}$-in. and the third with ⅜-in. electrodes.

The line was tested in progress by the usual tests on cut coupons. In the final test a hydrostatic pressure of 800 to 900 lb. was used. No leaks whatsoever were discovered.

LOADING RACK LOSSES OF NATURAL GASOLINE

By KENNETH S. RITCHE
Consulting Engineer

Cooling system using excess liquid reflux or recycling reflux vapors will cut down losses

CONTRARY to a general belief that the losses incurred in loading natural gasoline into tank cars are only losses of the lighter hydrocarbons, an extended series of observations at one gasoline plant has definitely proven the loading loss to be actually the loss of that much saleable natural gasoline.

The natural gasoline industry ever since its inception has always had to contend with very high loading losses. Practically every plant has installed equipment of one kind or another to reduce these losses as much as possible. The efficiency of such equipment varies widely. Although it is quite probable that these losses were substantially reduced for the low vapor pressure highly stabilized naturals, the chances are that the losses were not reduced proportionately as much as the plant's production of finished gasoline was reduced in changing over to the more stabilized product. The increased prices at which this product is sold and the sizable losses that still exist, particularly during the summer months, make the loading loss problem as important as ever in economical gasoline plant operation—even at depression prices for either high or low vapor pressure well stabilized products.

The data and results of an investigation of this problem are presented herewith. With these ideas in mind and the suggestions offered, some plant operators may find upon studying their loading losses again that substantial savings may be obtained and that the investment in the equipment needed to make these savings would be more than justified for present conditions. It is quite probable that the investment required will be much smaller than realized at first and the savings so large as to make a comparatively quick payout on the money invested. Later, as prices climb upward to the levels of several years ago, substantial additional profits will be derived from this investment.

Composition of Natural Gasoline Under Observation. All the finished gasoline under observation during this investigation was the product of very efficient high-pressure fractionation. Low-temperature fractional analyses of the composition of the stabilized gasoline made in several laboratories at various times always showed it to be propane-free. Therefore, the data and results presented herein are practically free from any influence of propane in the finished gasoline.

Graphical analyses made at the plant of the composition of the gasoline samples shipped to the laboratories gave very close checks for the three groups of hydrocarbons: butanes and lighter, pentanes, and hexanes and heavier. This proved the graphical method of analysis of composition to be sufficiently accurate for the purpose of this investigation and was used throughout.

All experienced gasoline plant men are familiar with the obvious fact that loading losses in summer are many times larger than the losses, if any, in winter. Generally it has been assumed, largely true when the finished product contained propane even of only a few tenths of one per cent, that the composition of the finished gasoline changed approximately in proportion to the size of the loading loss—that is, the more the loss the greater was the change in composition.

Data representative of that regularly taken during this investigation are presented in Table I and show that the composition of the loaded gasoline does not change approximately in proportion to the loading loss. It will be noticed that there was a loss in butane content between the "make" gasoline (sample of stabilized product taken before treating and storage) and the loaded gasoline and that this loss was larger in July than in April. However, the change in the butane content of the make between April and July was not so large and may have been partially offset by the change to a slightly lower recovery product. The significant point is that the loading loss had a proportionately greater increase between April and July than the butane content had changed—that is, the change in composition of the gasoline is not so great as the change in loading loss would indicate.

Furthermore, the gravity, recovery, and composition of the product leaving an efficient high-pressure stabilizer is in fact the saleable product ready for shipment and naturally shows less change with the seasons of the year than used to be the case with old-style stabilizers usually far less efficient. Then the product leaving them had to be adjusted to allow for storage and loading losses without leaving any undesirable material in the loaded product. Hence, the increase in loading losses in summer months is provided now by material other than the lighter hydrocarbons in the finished gasoline. This material is in reality the saleable gasoline as it is loaded into the tank cars.

TABLE I—COMPOSITION OF GASOLINE AND LOADING LOSS

	February, 1930		April, 1930				**July, 1930					
	Loaded	Loaded	*Make	Loaded	Make	Loaded	Make	Loaded	Make	Loaded	Make	Loaded
Gravity.....°A.P.I.	93.2	92.8	93.3	93.0	92.7	92.0	93.0	91.5	92.3	91.2	92.5	91.3
Recovery.....%	95.5	94.5	94.0	95.0	95.5	97.0	91.0	93.0	92.0	91.5	90.0	93.5
% over at 100°F.....	69.2	68.9	68.0	67.3	66.9	64.6	65.0	60.2	63.5	61.4	61.9	60.5
Reid Vapor Pressure..	27.0	26.9	26.1	26.2	25.3	25.6	26.3	26.5	26.5	26.8	26.4	27.0
Approx. Composition:												
Butane.....%	41.2	40.5	40.8	39.5	39.8	37.5	39.7	35.9	37.2	35.4	38.5	35.0
Petane.....	35.7	35.2	33.2	34.5	36.8	38.4	34.4	37.7	37.0	38.2	37.8	38.0
Hexane (Plus).....	23.1	24.3	26.0	26.0	23.4	24.1	25.9	26.4	25.8	26.4	25.7	27.0
Average Loss, gal./car	376	344	....	744	....	735	....	1618	....	1325	....	1826

*"Make"—Sample taken of finished gasoline before treating and storage.
**In May, stabilizer had been adjusted to make product with slightly lower recovery.

Effect of Temperature on Loading Loss. The more important part of the large amount of data gathered during this investigation is presented graphically in Fig. 1. The temperature of the atmosphere during the loading period each day is shown at the top. Lower down will be seen the temperature of the gasoline in storage and then the temperature of the gasoline at the

pump used to transfer the gasoline to the loading rack. Naturally, these three temperatures are closely related and hence their curves are quite similar.

The curve of the temperature of the cars before loading does not follow the other temperatures so closely largely because the cars did not remain at the loading rack equal periods of time before they were loaded, consequently their temperatures were not always at equilibrium with the atmospheric temperatures.

The temperature of the gasoline in the loaded cars follows a trend all its own. It is very significant that, except for the real cold weather in January, when the temperature of the gasoline in storage was practically the same as that in the loaded car, the loaded temperature hovered close to 50 deg. fahr. and changed very little—perhaps two or three degrees—from day to day and that during the very warmest weather it only reached 61 and 60 deg. fahr. once.

It was finally discovered that the temperature of the gasoline in the loaded car was the temperature of the initial boiling point of the gasoline in the Engler distillation of the sample taken from the car.

It had been observed previous to this discovery that the loading loss was greatly reduced whenever the temperature of the gasoline in storage was 50 deg. fahr., or below. If the reader will compare the low points of these two curves, he will notice the coincidence and that several times the loading loss was less than 100 gal. per car. Furthermore, it was observed that, when the temperature of the gasoline at the pump was at 50 deg. fahr., or less, the gasoline was handled from storage into the cars at a temperature equal to or lower than the temperature of the loaded gasoline in the cars and the loading loss accordingly was always less.

The two temperatures "gasoline in pump" and "gasoline in cars" were plotted on the same scale to show the close relationship between them and the loading loss. Thus, when these two temperatures are very close together, the loading loss is small but as they diverge, the greater the divergence the larger is the loading loss; such is the case in February and March, when the first generally large divergence occurs. The increase in the loading loss is, in general, proportionate to the increase in the divergence between the two temperatures. Likwise, further general large increases in loading losses occurred in April and the succeeding months as the curve of the pump temperature diverged in increasing amount from the temperature curve of the loaded gasoline.

Obviously, the more the gasoline at the pump had to be cooled to the temperature of the loaded gasoline the larger was the loading loss.

Thus, the loading loss was really the measure of the quantity of saleable gasoline used as the "refrigerant" to cool the tank car and its contents down to the temperature of the initial boiling point of the loaded gasoline.

Magnitude of Losses. These conclusions are more significant when it is considered that, despite the fact the gravity of the loaded gasoline was 91.0 to 92.0 deg. A.P.I. and the recovery 93.0 to 95.0 per cent, the loading losses on the hottest days early in August averaged 1500 gal. per car.

This loss is inordinately large considering that for loading out a tank car of 8100 gal. of gasoline another 1500 gal. is vaporized while cooling the car and its contents to the temperature required for no further vaporization for the particular loading conditions. It meant that for every 9600 gal. of finished gasoline taken out of storage only 8100 gal. or 84.5 per cent was shipped to the customer. If this loss did not exist, it would mean shipping an additional 1500 gal. of finished gasoline of the existing plant production now wasted for every 8100 gal. now shipped, which represents an increase of 18.5 per cent in the volume of gasoline sold and hence that much additional gross revenue—a sizable sum in itself.

In February, one of the cool months of the year, the loading loss averaged 399 gal. per car, and during the hottest days in August the loss had increased to an average of around 1500 gal. per car. A careful study of the data indicated that for a period of 267 days from the middle of February to the middle of November the loading losses averaged very close to 100 gal. of gasoline per car.

This represents a total loss of 267,000 gal. of saleable gasoline, assuming only one car daily was loaded out during this period. For the year of the investigation, the price received at the plant was more than 3.0 cents per gallon. Even at this figure, the loss was: 267,000 × $0.03 = $8010. The reader can use his own figures for computing the value in dollars and cents of this volume of gasoline at his plant.

Suggestions for a Cooling System. It is apparent that if the temperature of the gasoline being loaded into the cars was 50 deg. fahr., or lower, the loading loss would be very small, perhaps nil.

Since most gasoline plants now have high-pressure stabilizers, sufficient refrigerating material could be withdrawn from the liquid reflux in the tower and used in a system to cool the gasoline as it is loaded. The availability of this material is well known, as many gasoline plants make their own ice, and that for the employees through utilization of the refrigerating effect of the liquid reflux, which is a natural refrigerant.

The design and mechanical details of the loading rack cooling system naturally will depend upon local conditions. There is a variety of ways in which the reflux can be used efficiently. Where an abundance of reflux exists, it can be accumulated throughout the 24 hours in a large pressure storage tank and then used to do the cooling as the gasoline is loaded. Where the volume of reflux is scarcely large enough for efficient stabilizer operation, it would be necessary to install a compressor to recover the reflux vapors and recycle them after they had cooled the gasoline. With this recycling systhem, only a small amount of liquid reflux would be withdrawn daily for make-up purposes. The investment required will be comparatively small because the cooling system will not require such equipment.

Calculations for Volume of Reflux Required. In order to determine the feasibility of the preceding suggestions, calculations were made for estimating the volume of liquid reflux needed to cool the finished gasoline. The following example will give some ideas in designing a cooling system:

General data:

Gasoline in storage	Gravity	93.8° A.P.I.
	Recovery	90 to 91%
Maximum temperature in tanks		78° F.
Gasoline in tank cars	Gravity	92.0° A.P.I.
	Recovery	94.0%
Temperature of car before loading		79° F.
Temperature of car after loading		56° F.
Net contents of car at 56° F.		8070 gallons
Loading loss		1100
Total gasoline taken from storage		9170 gallons

Thermal data:

Weight of gasoline	5.25 lb. per gal.
Latent heat of gasoline	150 B.t.u. per lb.
Sensible heat of gasoline	0.6 B.t.u. per lb.
Reflux assumed to be propane-butane, which is cooled by water in a final cooler to a maximum temperature of 84 deg. fahr. in summer. When liquid reflux is expanded from 200 lb. to atmospheric pressure, latent heat of liquid would be	175 B.t.u. per lb.

Calculations:

A. Total heat removed in cooling now:

1. Net reduction in volume:

Volume of gasoline in car at 56° F.	8070 gal.
Corresponding volume at 60° F. 1.0034 × 8070 gallons =	8097 gal.
Corresponding volume at 78° F.	

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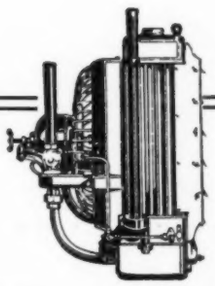

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8097 ÷ 0.985 = 8220

Net reduction in volume from 78° F. to 56° F. - - - - - - - - - - - 150 gal.

2. Sensible heat of total gasoline taken from storage:
   Total gasoline taken from storage - - - 9170 gal.
   (78 — 56) × 0.6 × 5.25 × 9170 gal. = 635,000 B.t.u.
3. Latent heat of vaporized gasoline (loading loss):
   (1100 — 150) × 150 × 5.25 = 748,000 B.t.u.
4. Heat removed from steel shell of tank caar in cooling from 79° F. to 56° F.:
   748,000 B.t.u. — 635,000 B.t.u. = 113,000 B.t.u.
5. Total heat removed by vaporized gasoline = 748,000 B.t.u.

B. Total heat removed in chilling gasoline in reflux cooler:
1. Assume no loading loss.
2. Minimum temperature of chilled gasoline required for its sensible heat to cool shell of tank car from 79° F. to 56° F.
   113,000 B.t.u./0.6 × 5.25 × 8070 = 4.44° F. below final loaded car temperature.
   Assume initial temperature of chilled gasoline is: 51° F.
   and after loading is: - - - - - - - - - 56° F.
   The sensible heat available for cooling car is:
   (56 — 51) × 0.6 × 5.25 × 8070 = 127,000 B.t.u.
3. Sensible heat to be removed from gasoline:
   (78 — 56) × 0.6 × 5.25 × (8070 + 150 gal.) = 570,000 B.t.u.
4. Total heat removed: 127,000 + 570,000 = 697,000 B.t.u.
5. Gallons of liquid propane-butane required to chill gasoline:

Assume complete expansion to atmospheric pressure.

Temperature of reflux leaving final cooling - - - - - - - - -	84° F.
Temperature of reflux in storage - -	—30° F.
Latent heat of vaporization - - - -	175 B.t.u. per lb.
Weight of liquid - - - - - - - -	4.5 lb. per gal.

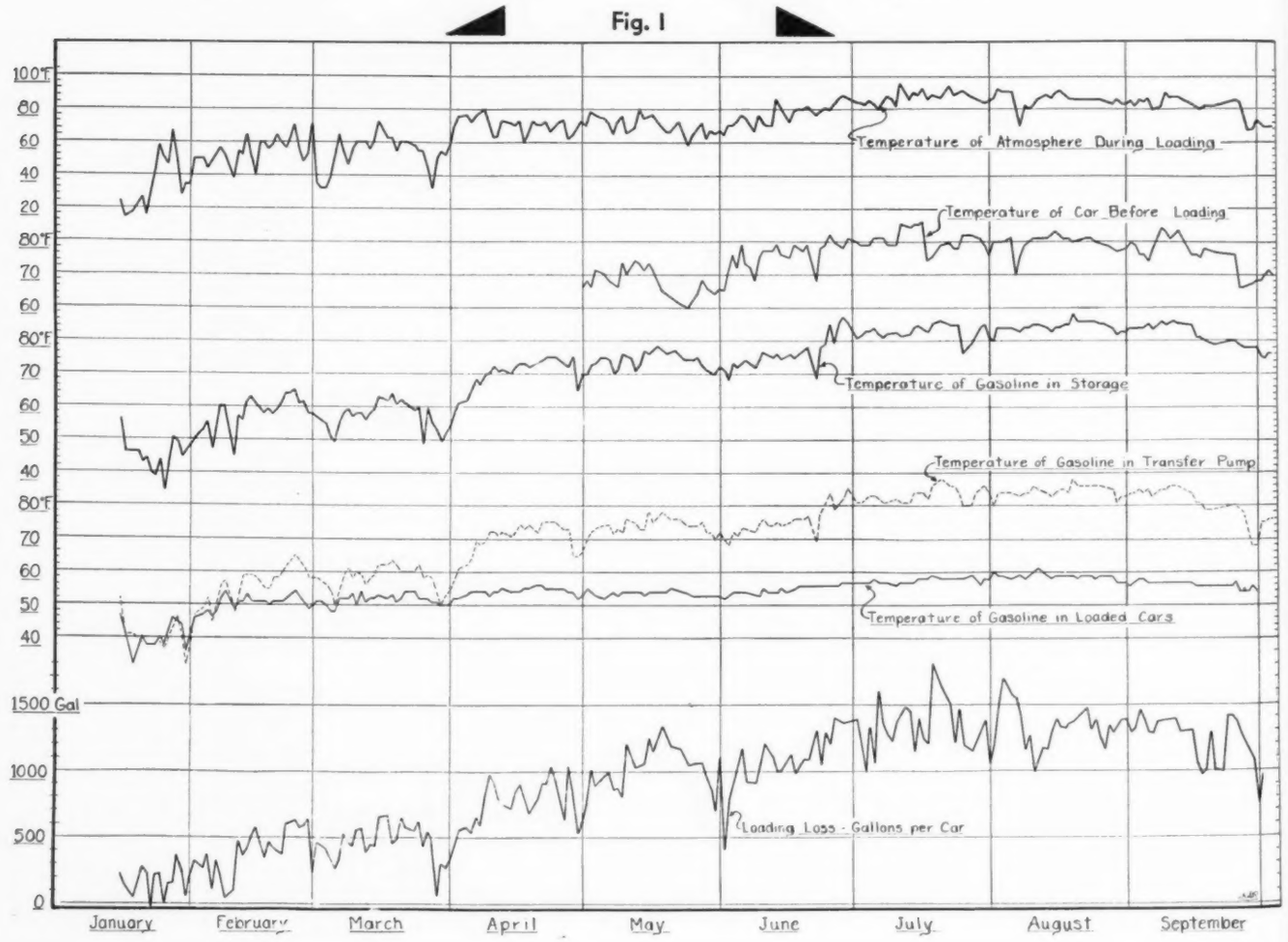
Temperature change in liquid:
84° F. to (—30° F.) = 114° F.
Available cooling effect in liquid:
(175×4.5)—(114×0.6×4.6) = 473 B.t.u. per gal.
Total volume liquid required:
697,000 ÷ 473 = 1475 gal.

Discussion of Calculations. Of the total heat of 748,000 B.t.u. removed by the loading loss, approximately 85 per cent or 635,000 B.t.u., were removed from the liquid gasoline itself in cooling the 9,170 gal. from 78 to 56 deg. fahrenheit. The remaining 15 per cent, or 113,000 B.t.u., were removed from the steel shell of the tank car in cooling it to 56 deg. fahrenheit. Thus, it is apparent that the greater part of the loading loss is due to the temperature of the warm gasoline being loaded instead of the warm steel shell of the tank car.

Since the warm steel causes the minor part of the loss, it is apparent that pre-cooling the gasoline being loaded below that desired for the loaded gasoline a balance can be reached to take care of the heat in the steel car. Calculations show that the temperature of the gasoline entering the car should be approximately five deg. fahrenheit lower than the temperature of the gasoline after loading; so that with a suitable cover to hold in the vaporization of gasoline during the first part of the loading of the tank car, these vapors should recondense during the latter part of the loading and be shipped out in the loaded car. In this way, no loss of saleable gasoline would result. It would be necessary to provide a safety valve to relieve excess pressure in case it should develop above the limits for the car.

The losses of the cooling medium will depend upon the installation used. Calculations show that approximately 1475 gal. of reflux would be required to produce 100 per cent cooling of the tank car of gasoline without any loading losses. If such could be attained in actual practice, then a reasonable amount of loss in the cooling material would be expected to take care of inefficiencies of heat transfer. For design purposes, it might be assumed that 500 gal. of reflux would be lost in cooling each car, and hence, approximately 2000 gal. would be used in loading each car.

Fig. 1



Two important points in the design of the system should be remembered: First, it will probably pay to recover as much as possible of the reflux vapors and recondense them for further use in the cooling system; this would relieve the load on the stabilizer. Second, through the use of suitable control instruments, the temperature of the gasoline being loaded can be readily controlled to maintain the desired vapor pressure of the loaded gasoline, thereby compensating for changes due to variations in the amounts of cooling required.

Results. One installation already in use has, with inefficient equipment, kept the loading loss down on the hottest days to approximately 250 gal. per car, resulting in a saving of about 1200 gal. per car for those days, or about 80 per cent. With suitable equipment, it is entirely reasonable to expect the loading loss to be held consistently below 100 gal. per car.

One argument has been advanced against the ideas suggested by this investigation and that is to continue using the old vapor recovery systems usually installed in gasoline plants. Such vapor recovery systems are rarely equipped to handle the variable peak loads from loading and recover efficiently the vapors from the cars. There are three points in favor of the cooling system: First, why return from each car loaded 1000 gal. of saleable gasoline vapors back through the vapor machines and on through the gasoline plant like incoming field vapors and throwing an unnecessary burden on the machines, still, exchangers, stabilizer, etc.? Second, why put these 1000 gal. of saleable gasoline through the treating plant again, causing an unnecessary use of chemicals and expense? Third, why lose part of the 1000 gal. of saleable gasoline in the inevitable losses of vapors going through the plant when the cooling system can be installed to load out at the desired vapor pressures without appreciable loading loss, if any, all saleable gasoline in the storage tanks?

It is apparent, therefore, that the cooling system suggested herein has several worthwhile advantages over the usual vapor recovery systems found at the loading racks of most gasoline plants. A carefully designed system to eliminate most of the loading losses could be installed to bring in large returns on the investment required to put into practical use the principles described in this paper.

Richard S. Gray, Oil Veteran, Dies

Richard S. Gray, known throughout the world of oil as "Uncle Dick," died last month at his home, 1508 South Cheyenne Ave., Tulsa, Okla., at the age of 77. Death was due to apoplexy. He had been ill for more than three years, suffering his first attack early in 1930 while serving as assistant superintendent of the land department of the old Prairie Oil & Gas Company.

Gray was born in 1856, near Clarion, Pa., and grew up in the environment of oil. Like most other Clarion boys, he worked as water boy and messenger for the early-day wildcatters and later became roustabout, tool-dresser and, before reaching voting age, a driller. While still a young man he became a contractor, ultimately associating himself with Kahle Bros., forming the drilling firm of Kahle Bros. & Gray. This firm had considerable production in various Pennsylvania fields.

At one time he was an operator in the Marion and Muncie fields of Indiana, afterward buying the Valley Oil Company refinery at Rouseville, Pa. Low prices caused this and some of his other interests to fail, so he accepted an invitation of Snowden & McSweeney to scout the Kansas and Indian Territory fields for them. While looking over the two areas, he met James O'Neil, then president of the Prairie Oil & Gas Company, and he soon became associated with the latter concern.

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Repackable Bradenhead

A NEW BRADENHEAD that may be repacked under high pressure has been placed on the market by Oil Center Tool Company, Houston, Texas. This OCT bradenhead is known as Type I, and is tested to 6000-lb. pressure. Repacking under pressure is done by simply removing a packing gland

and inserting an additional packing ring. It packs against the casing and also the casing collar, making two effective seals, according to the manufacturer. Packing used in the bradenhead is made of asbestos for protection against fire, although hydraulic packing is optional upon request.

The weight of the casing crushes two large asbestos rings under the casing collar, which sets on a steel junk ring, and four smaller asbestos rings set on the steel junk ring, sealing around the collar. This repackable bradenhead is made of forged steel in all required sizes. Under test it has been repacked under 3000-lb. pressure.

Protective Coating for Tanks

RUST growth on crude oil tanks, exposed pipe lines, ladders, steelwork connecting tanks, fences and any exposed metal surfaces in refineries, is said to be smothered by Saverite, a protective liquid coating.

According to the manufacturers, National Rust Prevention and Waterproofing Co., 31st and S. Main Streets, Los Angeles, Calif., Saverite is a treatment that penetrates directly to the new metal not yet attacked. From this point out to the surface, it fills all pores and eliminates any absorption of moisture, air, fumes, or other deteriorating agencies. Saverite then solidifies, creating a tough and elastic sealed protective coating that can be used as a prime coating for paints.

It is also said that Saverite is equally effective in reviving the life of old paint coatings, as a vehicle for aluminum powder, as a rust preventive inside gasoline storage tanks or to prevent steel from rusting on the bottom of tanks set on porous foundations. Wet and dry rot in wood is stopped by Saverite, it is claimed, as is also the checking of wood due to the heat of the sun.

Oilwell Tubing Crown Block

THE NEW Oilwell Type 33 Tubing Crown Block has been developed especially for the East Texas field, although its use is by no means limited to that one locality. It is a sturdy block, designed for long life, maximum convenience and dependable,

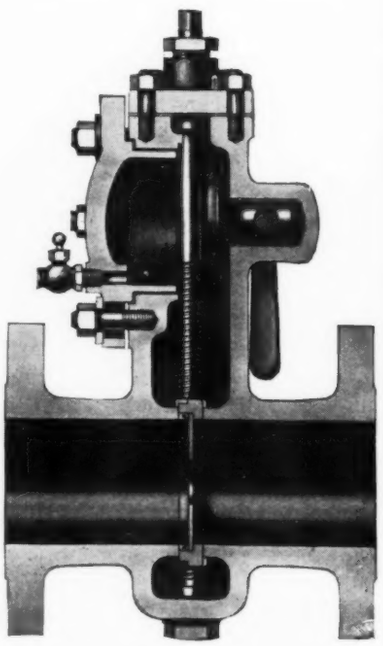
trouble-free performance, according to the manufacturer.

It is regularly furnished with three beams and three sheaves, three beams and two sheaves or two beams and two sheaves. A beam can be easily added or removed in the field, and the bearing housings are clamped in place so that the sheaves can be readily shifted to any desired positions even after the block is set up in the derrick.

The beams are strong structural-steel I-sections. Ten-inch beams are furnished for handling the heaviest loads with a wide margin of safety. Eight-inch beams are furnished for lighter service. The sheaves are 22-in. outside diameter.

The nearest Oil Well Supply Company representative will be glad to furnish further information.

Lucas Orifice Fitting



SOUTHWEST WELDING & Manufacturing Company of Alhambra, Calif., has recently introduced a new fitting that because of its extreme compactness, light weight yet sturdy construction, adapts itself to any installation regardless of space limitations. Manufacturers claim many advantages for this fitting, which has been designated the Lucas orifice fitting. The necessity of head room for an elevator screw or for disc removal has been eliminated. With it has also been eliminated the likelihood of damage occurring when the orifice plate is removed at top of a fitting. The elevator stem no longer screws out of the top plate, but remains in position similar to a non-rising stem gate valve. In the second place, the Lucas orifice fitting is so constructed that the orifice is

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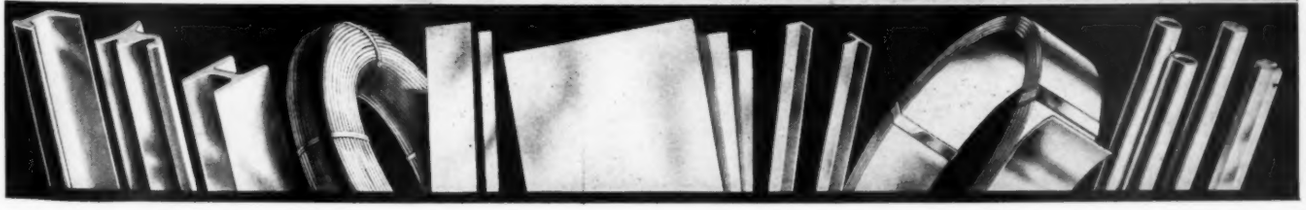
Our skilled technologists are available to assist you in securing the particular sheet or light plate best suited for your requirements, and are at your service if desired. Literature descriptive of these products will be sent promptly upon request.

AMERICAN SHEET AND TIN PLATE COMPANY, Pittsburgh, Pa.
SUBSIDIARY OF UNITED STATES STEEL CORPORATION

USS STAINLESS Steel Products are also supplied by these subsidiaries of the United States Steel Corporation: AMERICAN STEEL & WIRE COMPANY, Chicago; Cold Rolled Strip Steel, Wire and Wire Products. CARNEGIE STEEL COMPANY, Pittsburgh; Bars, Plates, Shapes and Semi-Finished Products. ILLINOIS STEEL COMPANY, Chicago; Bars, Plates, Shapes, Special and Semi-Finished Products. NATIONAL TUBE COMPANY, Pittsburgh; Pipe and Tubular Products.

USS Chromium-Nickel Alloy Steels are produced under Licenses of Chemical Foundation, Inc., of New York; and Fried. Krupp A.G. of Germany.



absolutely centered in the fitting as well as being concentric with the axis of the pipe, and is positively locked during operation. This feature permits the flow of gas or liquid to come from either direction, and the installation of the fitting may be made at any angle desired. The third outstanding advantage of the Lucas fitting lies in its elliptical design, doing away with the necessity of rib reenforcing and lightening the various sizes of Lucas orifice fittings from 10 to 40 per cent, depending upon the model. The extreme simplicity and compactness of disc removal mechanism and chamber, relieves all hazard from plate changing. The throwing of a single lever brings a globe type valve disc directly against the plate carrier, in turn sealing it against the machined seat of the body. Line pressure holds the valve closed. The machining and finish of the fitting is of the highest quality. The positive stops, which control the location of the disc holder in its top and bottom position, are turned at the same time the fitting is bored, assuring precise centering. The disc holder is bored while in line position, guaranteeing perfect alignment and internal bore smoothness. Pressure taps are exactly one inch from center of orifice disc, and are of adequate size to prevent stoppage. A drain tap is provided on each side of the sediment pocket, permitting cleaning straight through or draining from either side. All other operations take place well above the top of the pipe.

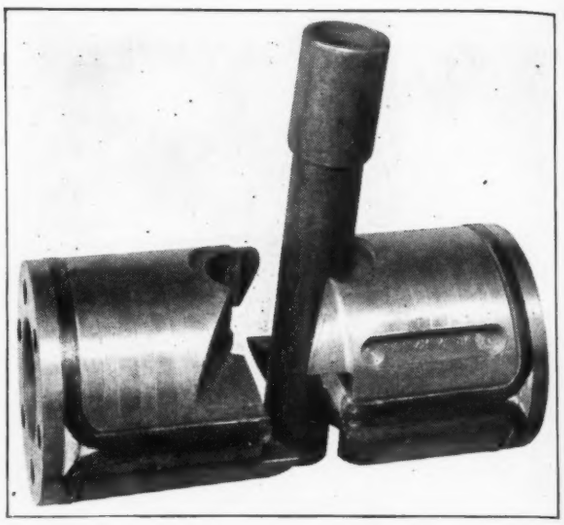
Reclosing Device for Oil Circuit Breakers

AN INEXPENSIVE, direct-acting reclosing device, designated as Type SM, has been developed by the General Electric Company, Schenectady, N. Y., for use with oil circuit breakers. This attachment will reclose a breaker one, two or three consecutive times, with equal time intervals between, when the breaker is tripped by overload. When the load again becomes normal after a reclosure, the attachment will return to its regular position and the breaker will remain closed. Should the overload still exist after the last reclosure, the breaker will remain locked open and it will be necessary to close it manually before any further automatic operation takes place.

The attachment is a mercury-tube device in which timing is obtained by running mercury through an orifice into a reclosing contact chamber. The tube has sealed-in contacts that do not deteriorate or require care. The number of consecutive reclosures that the equipment will make, and the interval between reclosures are fixed during the process of manufacture. A new tube, however, can be readily substituted if a different number of reclosures or another time interval is desired.

The attachment is direct connected to the breaker mechanism and is available with both solenoid and motor-operated breakers. It can be furnished with outdoor breakers and switch house equipments. It can also be supplied for use with indoor breakers that have various mountings, such as pipe or angle iron and metal-enclosed.

Cameron Blowout Preventers



CAMERON IRON WORKS, Houston, Texas, is equipping all new Cameron Blowout Preventers with new type pipe centering rams, designed with wing guides to pull the drill pipe to the exact center of the hole when the preventer is being closed. The improved safety rams are interchangeable with the type used in the old-style Cameron preventers, thus Cameron preventers in the field can be given this modern feature in blowout prevention.

According to the manufacturer, the pipe centering rams do away with the original flat surface on each side, and therefore with the possibility of the rams not coming together flush when closing pressure is applied.

These rams offer another advantage in that the wing guide corners extend above the packing far enough to protect it against damage from contact between the drill stem and the packing on the corners, where wear previously resulted.

More detailed explanation will be furnished by the Cameron Iron Works upon request.

Murex Electric Welding

A NEW development in arc welding, particularly suited to the joining of heavy plates, is announced by the Metal and Thermit Corporation.

Known as Murex Straight Cap Welding, the new process does away with all need for "veeing" or grooving of plate edges. Plates may be used just as they come from the mill. Greater welding speed, as well as appreciable reductions in cost, are claimed. In fact, the developers of the process say that it cuts welding time in half, and, by eliminating all preparatory work and reducing the quantity of weld metal required, achieves real economy in welding heavy plates. In addition, it is stated, tests conducted by outside laboratories show that straight gap welds are physically superior in many ways to those in which the usual "V" or "U" gaps are employed.

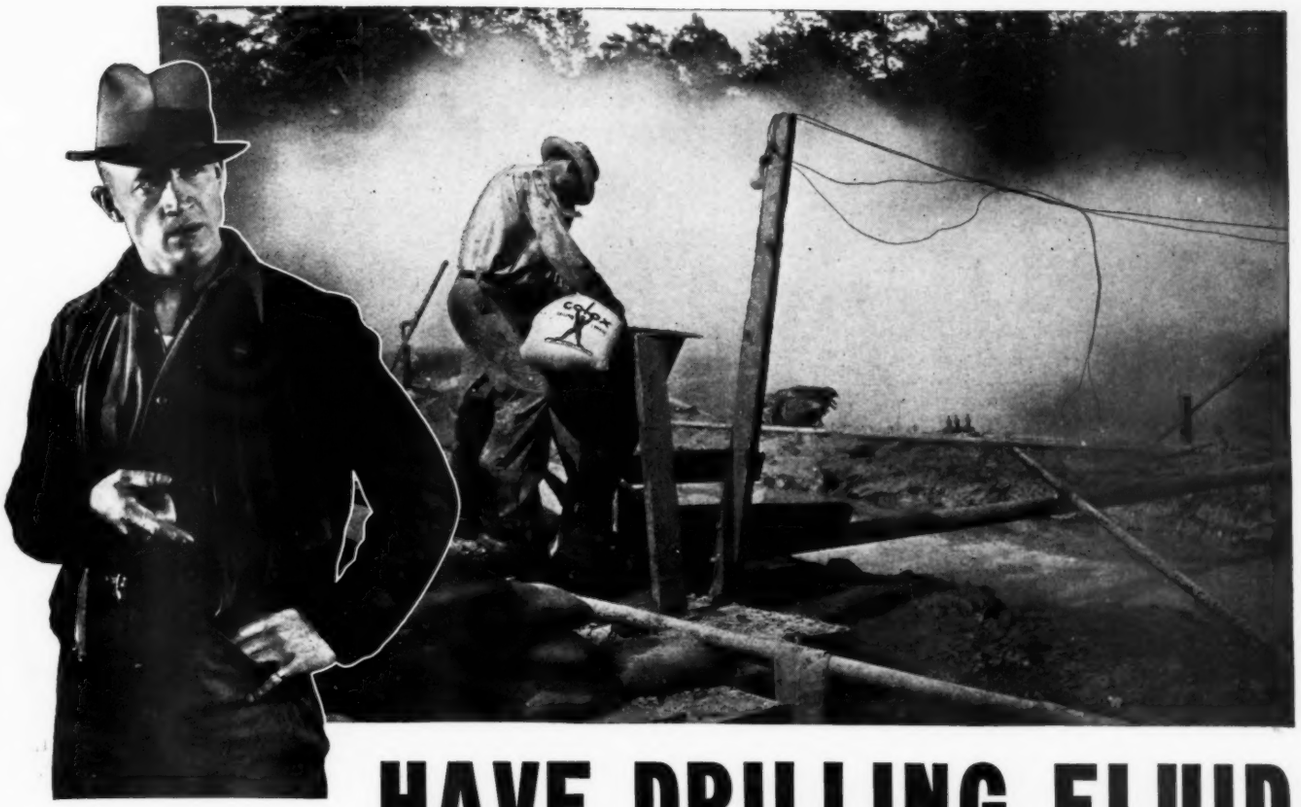
At the same time, the above company announces an addition to its line of Murex Heavy Mineral Coated Electrodes. The new unit, Murex Universal, is for use on mild steel and may be employed in either flat, vertical, or overhead work. Smooth, clean deposits of unusually high tensile strength and ductility are obtained consistently, it is said, on any of these classes of work.

Literature covering both of these items may be had from the Metal & Thermit Corporation, 120 Broadway, New York, N. Y.

Wire Rope Socket

A NEW product, known as the Fiege Tiger-Claw Wire Rope Socket, has been developed and placed on the market by the American Steel & Wire Company, 208 La Salle Street, Chicago, Illinois. The manufacturers claim that this socket offers 100 per cent cable strength and solves in a simple manner many perplexing and sometimes costly problems.

The installation of the tiger-claw socket requires no flame or hot metal and may be attached quickly, with ordinary labor, in the field. The device is composed of three parts: a socket, a sleeve and a plug.



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BOOKS *of the* TRADE

PROCEDURE HANDBOOK OF ARC WELDING DESIGN AND PRACTICE. The Lincoln Electric Company, Cleveland, Ohio. 434 pages, 500 illustrations. Price $1.50.

This handbook has been prepared to present in convenient form for ready reference the basic information on arc welding. Its contents include not only a complete description of the arc welding process in its various forms, but also the essential data for its use in welding various types of steels, iron and non-ferrous metals.

Design being closely allied with the application of welding, a large portion of this handbook is devoted to designs for arc welded construction of machinery and structures. Many examples of machinery elements and units are included, as well as various forms of structural details applicable to many types of structures.

A section has been devoted to typical applications of arc welding in manufacturing, construction and maintenance.

SYMPOSIUM ON MOTOR LUBRICANTS. American Society for Testing Materials, 1315 Spruce Street, Philadelphia, Pa. 121 pages. Price $1.25 in heavy paper binding, and $1.50 in cloth binding.

The seven technical papers and extensive discussion that make up the published "Symposium on Motor Lubricants" were presented at a joint meeting of the A.S.T.M. and the Metropolitan Section of the Society of Automotive Engineers. Subjects covered include: service requirements, viscosity, carbon deposits, oil consumption, service changes, engine design as affecting oil performance, and aircraft engine lubrication. Many of the problems discussed in the symposium are controversial and the participation in the discussion by outstanding technologists in the petroleum and automotive industry resulted in a general advancement toward agreement on some of these factors. The authors have used diagrams and tables extensively to give a quick and clear presentation of data.

EVAPORATING, CONDENSING AND COOLING APPARATUS. By E. Hausbrand and B. Heastie. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York. 503 pages. Illustrated. $8.00.

This book simplifies the calculations involved in the design of heat transfer equipment by logical explanation of tables and formulas, systematically arranged for ready reference. A general discussion is given of the transfer coefficient and mean temperature difference for conditions of parallel and opposite flow of fluids. This is followed by a detailed treatment of various ways of supplying heat, by direct fire, by hot liquids, by superheated steam, and by saturated steam, including both steam heating by means of coils and tubes, and by double bottoms and wide jackets.

The subject of evaporation and evaporators is developed from the basic physical principles influencing the quantity of evaporation required and the lowering of the boiling point in a vacuum, to details of capacity, heat requirements, effective transfer surface and the other quantities upon which the design is based. Modern types of evaporators and their accessories are fully described in concluding the book.

PRECAUTIONS IN WELL PULLING. Department of Accident Prevention, American Petroleum Institute, Dallas, Texas. 12 pages. Price 25 cents.

This accident-prevention manual is a compilation of material based on the experience of those engaged in well pulling throughout the oil industry. Adherence to the suggestions given should prevent many injuries to workers, and in turn

prevent the dropping of many strings of tubing, many fishing jobs, and other causes of unnecessary expense.

BROWN'S DIRECTORY OF AMERICAN GAS COMPANIES, 1933. Robbins Publishing Company, 9 East 38th Street, New York, N. Y. $15.00.

The 1933 Brown's Gas Directory contains an alphabetical list of all gas companies, holding and operating; names of officers and department heads; number of customers; miles of mains and sizes; calorific value and specific gravity of gas; volume sold annually to all classes of customers; rate schedules; type and quantity of appliances in use; unit sales last year; retail stores operated; a complete list of cities served with gas; a list of gas associations and public service commissions and a catalog of gas equipment.

PETROLEUM PRODUCTS AND LUBRICANTS. Published by the American Society for Testing Materials, 1315 Spruce Street, Philadelphia, Pa. 292 pages. $1.25.

This publication brings together in convenient form the many A.S.T.M. standard and tentative methods of testing petroleum products, together with the 1933 report of Committee D-2 on Petroleum Products and Lubricants. In all there are 51 test methods given. Many of these have been approved by the American Standards Association and the American Petroleum Institute.

Revisions in several of the standard methods were adopted in 1933 by the society. These are given in their latest form. Several of the methods were adopted as standard this year, having previously been approved as tentative.

TRADE LITERATURE

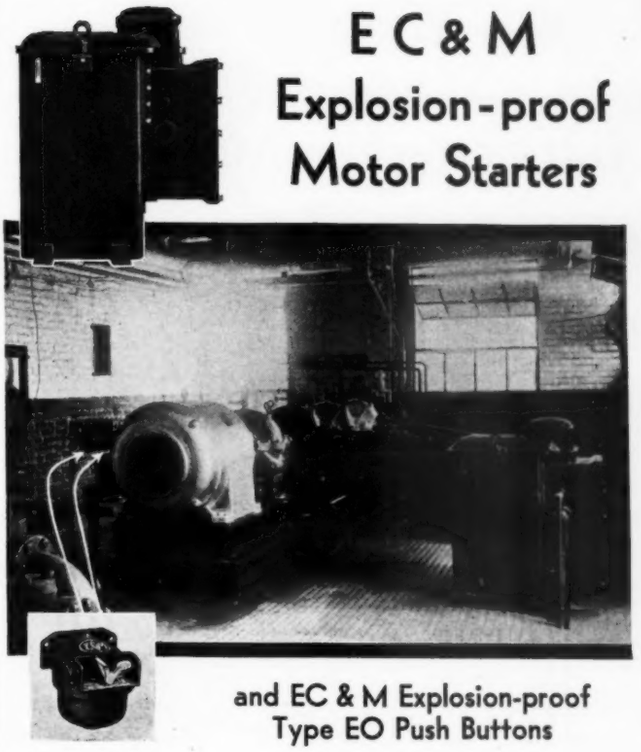
CENTRIFUGAL PUMPS. Fairbanks, Morse & Co., Chicago, Ill., has announced publication APB221.3, which describes its 5810 line of single-stage split-case centrifugal pumps for capacities up to approximately 3000 g.p.m. and for heads up to about 300 ft. at 1750 revolutions per minute. The Fairbanks-Morse pumps described represent only one of the complete lines offered by them for a wide variety of services.

GAS ENGINES. Worthington Pump and Machinery Corporation, Harrison, New Jersey, has recently released Bulletin S-550-S5. It describes the company's vertical four-cycle type gas engine of 180 to 360 horsepower.

PRICE-TRAWICK, INC., announce publication of a new folder on P & T Kick-Off Units. It is ready for distribution from any of the following offices of the company: Fort Worth, Oklahoma City, Los Angeles and Stroud, Okla.

MOTOR MECHANIC'S HANDBOOK — No. 33. The Technical Service Department, South Bend Lathe Works, South Bend, Ind., will mail free a copy of the above entitled 32-page booklet that shows the latest practical methods for handling dozens of major maintenance jobs encountered in keeping up such equipment as tractors, trucks, automobiles, power shovels, gasoline and Diesel engines, pumps and general mechanical equipment.

VERTICAL MOTORS. Vertical motors is the subject of a new loose leaf bulletin sheet issued by the Wagner Electric Company, 6408 Plymouth Avenue, St. Louis, Mo. It illustrates and describes the three different types of vertical motors, and by means of many illustrations of applications, explains how horizontal-type motors can be mounted vertically.



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Enclosed in a case sufficiently strong to safely withstand an internal explosion without transmitting flame to the surrounding atmosphere. It will provide a 100 per cent safe job in accordance with the requirements for Class 1, Group D Hazardous Locations.

The operating mechanism, current-carrying parts and entire design will be of larger-than-average construction. These features of extreme sturdiness will permit this equipment to stay on the job longer without attention.

If it is your practice to make periodical inspections on control equipment every six months or once a year, you will find on examination at this time, that moisture and sweating have taken no toll—corrosion has been eliminated from within by oil-immersion. This has long been a feature of EC & M Automatic Motor Starters.

EC & M Explosion-proof Motor Starters are available for full voltage or reduced voltage starting of both low and high voltage motors. Be familiar with their design, which means less maintenance—longer periods of operation without requiring "opening up." Write today for complete information describing this dependable and economical explosion-proof control equipment.

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Oil operators should make certain these days that they are getting the most for their money.

In wells where production has fallen off pumping equipment should be replaced by that specifically designed to do the best job.

If present equipment will not increase production, the equipment should be altered so that the pump and rods represent the minimum investment in relation to the oil produced.

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Death of Charles Piez

Charles Piez, who with Charles M. Schwab, directed the wartime work of the Emergency Fleet Corporation, died October 2, at the Garfield Hospital, Washington, D. C. Mr. Piez was chairman of the board of Link-Belt Company, Chicago. His last appearance in official circles was as a dinner guest of the President at the White House recently.

Mr. Piez was a past president of the American Society of Mechanical Engineers. He served twice as president of the

Illinois Manufacturers' Association. The deceased was 67 years old. While pneumonia was the direct cause of his death, his health had been failing for the past five years, and since February, 1932, he had been wholly inactive in business. Last May Mr. Piez moved from Chicago to Washington, where he made his home at the Shoreham Hotel.

Largely as a result of his fame as an organizer and manager of industry, Mr. Piez was selected by Edward N. Hurley, then chairman of the U. S. Shipping Board, in November, 1917, to be vice-president and general manager of the Emergency Fleet Corporation, to carry out the nation's shipbuilding program. As the chief executive of this mammoth enterprise, and later succeeding Mr. Schwab as director general, Mr. Piez advised upon and directed the expenditure of three billion dollars. He had control over 600,000 persons employed in the shipyards and fabricating plants, and in industries furnishing supplies to the yards.

Mr. Piez resigned on May 1, 1919, as director general, to return to his former business. He continued as president of the Link-Belt Company until 1924, when he became chairman of the board, and remained as chief executive until February, 1932. He was a member of the following engineering societies: American Institute of Mining and Metallurgical Engineers; Society of Naval Architects and Marine Engineers; Western Society of Engineers and Engineers' Society of Northeastern Pennsylvania.

Born in Germany of naturalized American parents, Mr. Piez received his technical education as a mining engineer at the School of Mines, Columbia University. Like many other men who later became leaders in the business world, his own earnings contributed largely to pay for his education. Immediately after he was graduated in 1889, he entered the employ of the Link-Belt Engineering Company, in Philadelphia, as an engineer-draftsman. After he had attained to the position of chief engineer and general manager of the

Philadelphia works of that concern, 17 years later (in 1906), he was elected president of a consolidated organization of the three related companies, the Link-Belt Machinery Company, Chicago, the Ewart Manufacturing Company, Indianapolis, and the Link-Belt Engineering Company, Philadelphia.

Experiments Show Advantage of Full Spark Advance with Ethyl Gasoline

A full spark advance adjustment that gives full power at all car speeds is possible with motor fuel containing tetraethyl lead, it is shown by experiments at the Detroit Engineering Laboratories of the Ethyl Gasoline Corporation, owned jointly by General Motors Corporation and the Standard Oil Company of New Jersey. When using ordinary motor fuel it was found necessary to retard the spark in lower speeds in order to avoid knocking.

The advantage of the full spark advance, which is accomplished by completely releasing the distributor brake, is quicker acceleration from a low speed. Using tetraethyl lead, car speed was increased from 10 to 50 miles per hour in 1.05 seconds less time than with ordinary gasoline, because the full spark advance curve was available at all speeds. The retarded spark, necessary at low speeds with ordinary fuels to avoid knocking, delays the car in reaching its maximum speed.

A 1933 V-8 Ford was used in the tests. The distributor brake was automatically released on the car using ordinary fuel when it reached 23 miles per hour, to give full spark power for both cars.

The importance of getting off to a fast start was shown by the fact that the Ford using tetraethyl lead climbed a 12 per cent grade in 15 seconds less time than the one using ordinary gasoline, the first car reaching an approximate speed of 28 miles per hour, and the second, of 17 miles per hour. Tetraethyl lead, permitting a full spark advance at all speeds without a knock, enabled the car to reach its maximum speed quicker.

In tests made on a 7 per cent grade and on level ground, the car using tetraethyl lead reached its maximum speed fist, although the difference in time was not so noticeable because both cars reached 23 miles per hour in a short time and thereafter had identical spark adjustments.

Acceleration tests were made with the same passenger load and the same distributor housing setting for each fuel.

New York Office for D. W. Haering and Company

D. W. Haering and Company, Inc., Chicago, Ill., water consultants and manufacturers of H-O-H Water Treatments, announce the opening of a New York office at 1451 Broadway, New York City, and the appointment of William Wright as district manager.

A. S. Maxwell Dies

A. S. Maxwell, for many years sales and advertising manager for J. H. Williams & Co., New York, Buffalo and Chicago, died at his home in Garden City, Long Island, N. Y., last month. He had suffered for the past two years from a severe rheumatic condition that fatally affected the heart.

Mr. Maxwell, who was widely known in many industrial fields, is survived by his widow, son and daughter.

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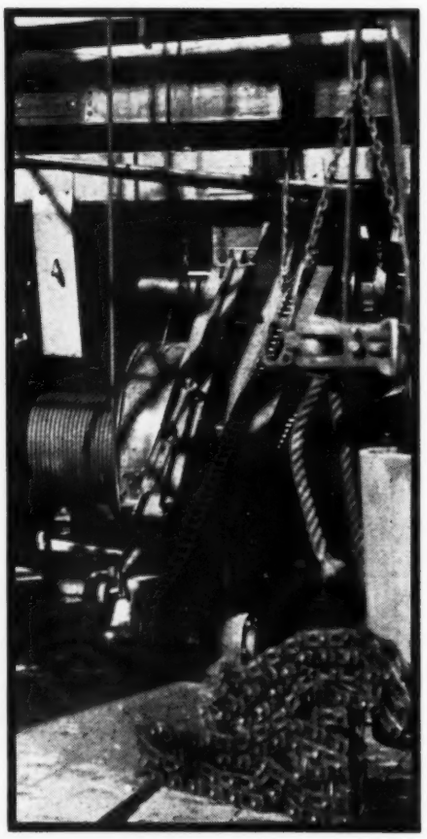
First National Bank in Dallas

Rotary Chain A Vital Part of Drilling Machinery

ROTARY sprocket chain is in general use for transmitting power in rotary drilling machinery. There is a reason for this. It is generally conceded that the heavy duty imposed on drilling machinery is probably as severe as that to be found anywhere, and explains the adaptability of the sprocket chain in the oil field.

Among the many factors that enter into the degree of service obtained, the greatest perhaps is the care that the driller exercises when engaging the clutch. Square jaw clutches being in general use, excessive loads can be put on the chain, especially in deep wells and where engines of high horsepower are used. There are three sizes of chain in standard use and these are known as A.P.I. Number 3, Number 3½ and Number 4, and have a chordal pitch of 3.075, 3.500 and 4.063 in. respectively. According to A.P.I. specifications, a plus tolerance of 0.008 in. per pitch is allowed. In addition, the roller diameter and width and distance between side bars is stipulated. For the three sizes mentioned, the roller diameter is 1¼ in., 1⅝ in. and 1¾ in.; roller width $1\frac{7}{16}$ in., $1\frac{7}{16}$ in. and 1⅞ in.; and the distance between side bars 1½ in., 1½ in. and $1\frac{5}{16}$ in. respectively. The shipping length for standard stock is 10 feet.



Rotary chain on a drilling test in Oklahoma

About seven or eight years ago when the A.P.I. standards were being developed, it was found that the layout of rotary drilling machinery was in a large part responsible for heavy wear and tear on rotary chains. This was corrected by co-ordinating engineering design to meet the needs of oil field use and adapting the layout to the chain type of drive. In devising these standards much attention was paid to the form of sprocket tooth, and the design ultimately adopted was based on results of exhaustive tests in the field. These tests had the co-operation of the manufacturer and the operator so that the practical aspects of the difficulties were eliminated.

With square jaw clutches in use, excessive loads are frequent on the transmission, and rotary sprocket chain has well filled the service requirement demanded of it. An idea of the chain pulls in rotary drilling can be gathered from theoretical calculations based on steam pressure at the manifold. For example, with a steam pressure of 225 lb., on a three-speed drawworks the engine chain pull will be about 17,000 lb., the low-speed chain pull about 44,000 lb., and the rotary table chain pull 900 pounds. For 150-lb. steam pressure the maximum theoretical engine chain pull will be about 11,000 lb., low-speed chain pull 29,000 lb. and rotary table chain pull about 6000 pounds. On a four-speed draw works the chain pulls will be proportionately higher.

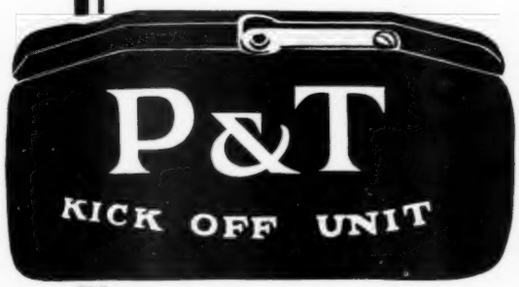
Manufacturers have concentrated on their product in producing a chain that will give maximum service. How well they have succeeded in this will be gathered from the fact that with average good usage a set of chains will be good for from 20,000 to 25,000 ft. of hole, or equivalent to four or five wells 5000 ft. deep, before replacement is necessary. Special attention to sprocket centers enables the chain to be used under favorable conditions so that they are fairly taut when in operation, thus cutting down the resultant wear and tear that is so prevalent when chains are run too loose.

In recent years attention to design has been such that many of the early troubles in the use of sprocket chain drives have disappeared.

Chains today can be had that are easily replaceable. Links can be removed when required and changes made with a minimum of effort and shut down time. For example, the Link-Belt rotary Red Head chain recently brought out was specially designed for rotary drilling service and conforms to established A.P.I. standards. Pins and bushing holes are finished to precision limits and the metal of the side bars is so distributed that maximum strength is obtained. The A.P.I. Number 4 chain has an ultimate strength of 100,000 lb., and A.P.I. Number 3 has an ultimate strength of 45,000 pounds. The Number 4 chain is being used successfully on the engine and draw works drive on wells 5000 ft. deep, and the Number 3 chain for the rotary table drive. There is an integral lug on the side bar into which the T-head of the pin fits securely. The pins are of forged nickel chromium steel machined and heat treated, and are locked securely in position on the lug. By this means the full diameter of the pin is utilized, increasing the strength and shear value. Each 10 ft. roll of chain is provided with cotter keys for convenience in changing links in the field. Trouble due to tight fits is eliminated. The rollers have an ample bearing area and are easily lubricated. These desirable features make repairs easy and increase the flexibility of the chain in use. The cotter keys are of nickel alloy steel and are heat treated. The end is spread, thus insuring a non-shifting retainer.

In this particular chain the roller is of the Link-Belt curled type and is made of rolled nickel chromium alloy steel heat treated. The curled roller acts as a shock absorber, thus relieving sprocket teeth and chain joints of high impact loads.

P & T KICK-OFF UNITS will



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There is a type of P & T KICK-OFF UNIT that will fit your needs

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The Shaffer Rotating
BLOWOUT PREVENTER

The Shaffer Rotating Blow-Out Preventer consists of a steel bowl in which is a complete packing assembly that is held in place with a bonnet. This assembly provides for packing either around the grief stem or around the drill pipe; and both types may be furnished with each preventer. . . . The essential part of the assembly is a long sleeve which rotates within the packer and which is carried on two sets of ball bearings to eliminate friction. Inside this are steel bushings and rings of oil-resisting rubber packing that are shaped to fit a particular sized Kelley or pipe. These prevent leakage as they revolve with the Kelley or pipe. The ball-bearing sleeve is carried by a stationary packer in the body of the head and is packed off by a heavy ring. Packing is in turn provided to prevent leakage between the rotating sleeve and the stationary packer. Complete protection is thus provided when the well is drilling.

When combined with the Shaffer Cellar Control Gates and other necessary Shaffer equipment, the Rotating Blow-Out Preventer provides complete well control at all times with the additional advantage of offering no interference to drilling. Danger of frozen pipe is diminished, mud circulation is used to its greatest advantage, and gas pockets or high pressure water zones are handled with ease. The Rotating Blow-Out Preventer offers a means of overcoming adverse conditions as well as preventing trouble.

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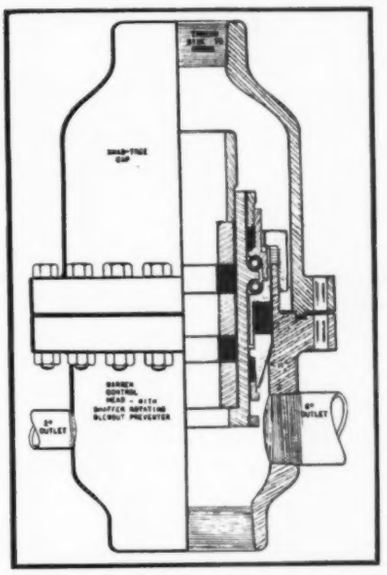

When Used with the Warren Head

The Rotating Blow-Out Preventer can also be supplied with a Warren Control Head so that shut-offs or pipe connections can be made even with pipe in the hole. The patented flange feature provides a means of making any type of connections desired with the well under complete control; yet with the advantage of being able to drill always available.

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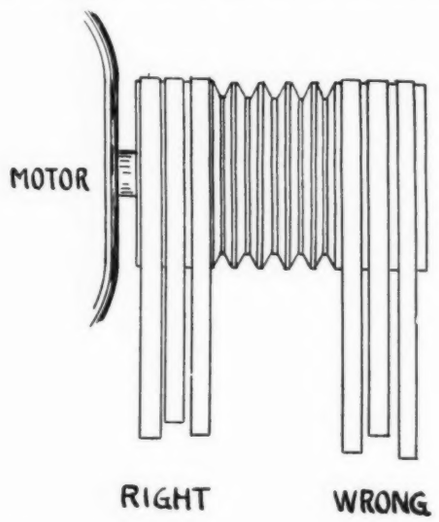
Improving A V-Belt Drive

By W. F. SCHAPHORST
Mechanical Engineer

ON numerous occasions I have seen V-belt drives improperly belted as indicated by "wrong" in the accompanying sketch. That is, when the sheave is only partially belted with only two or three ropes, the ropes are placed at the "end" of the sheave, as far away from the motor bearing as possible. The explanation for placing in that position is: it is the easiest place to put the ropes.

The correct way is to place the ropes as close to the motor as possible as indicated by "right" in the sketch. By so doing



there will be less bearing pressure owing to the smaller leverage of the ropes through the shorter distance. In any belt drive, the greater the distance of the "center of belt pull" from the center of the bearing, the greater will be the pressure of the shaft against the bearing, and, consequently, the greater will be the friction and loss of efficiency.

This also makes clear one of the reasons why double-ply belts are preferable to single-ply; the center of pull of a double-ply belt is closer to the center of the bearing.

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FORT WORTH, TEXAS

Continental Supply Opens Headquarters in Dallas

Effective October 16, the Continental Supply Company began transacting its international business from new headquarters in the Continental Building, Commerce and Lane Streets, Dallas, Texas.

The company's operations at St. Louis, Mo., were suspended on October 12, so that all files and equipment might be brought to Dallas and installed in time for every department to be functioning with as little delay as possible. The company brought 82 employees, who, with their families, represent a total of 193 persons.

Upon deciding to locate in Dallas, Continental purchased the old Crowdus building, which was completely remodeled at a cost of approximately $80,000. It is now a most modern office building. Continental will occupy the first three floors, renting office space on the upper two floors. Already a number of these offices have been taken by concerns affiliated through distribution facilities with Continental Supply Company. The front portion of the lower floor has been converted into a display room.

The Continental Supply Company is a subsidiary of the Youngstown Sheet and Tube Company, Youngstown, Ohio, whose tubular products it distributes through 48 stores in the Mid-Continent area. Continental also distributes in the Mid-Continent the products of Emsco Derrick and Equipment Company of Los Angeles and Dallas, in addition to a number of other nationally and internationally known products.

"The move to Dallas was made to place the company in closer contact with the oil fields," W. J. Morris, president, said. "This factor will enable us to give better service to our field customers. I think we have made a good move in coming to Dallas and the citizens of Dallas have been most kind and helpful."

American Petroleum Institute Will Diagnose Petroleum Situation

The petroleum industry in the United States, as it exists under influences set to work through the National Industrial Recovery Act, will be the subject of a thorough diagnosis when the American Petroleum Institute meets in its fourteenth annual assembly at Chicago, October 24, 25 and 26.

One of the principal sessions will be held on Wednesday morning, October 25, when Harold L. Ickes, secretary of the interior and federal oil administrator, and Wirt Franklin, chairman of the Planning and Coördinating Committee for the industry, will review the busy weeks in the late summer and early fall that brought the machinery of the Code of Fair Competition for the petroleum industry to functioning.

Axtell J. Byles, president of the American Petroleum Institute, will deliver his address at a general session on Tuesday afternoon and at the same time the work of the American Petroleum Industries Committee, with H. T. Klein as chairman and Baird H. Markham as director, will be presented. The committee has extended its activities into every section of the United States in combatting bootlegging, tax evasion, and other forces inimical to the industry and the public since it was formed last November.

Eleven group sessions of the Divisions of Production, Refining and Marketing are scheduled for the three days' meeting, and nearly 100 of the Institute's working committees will hold meetings. The Division of Production will hold five sessions; the marketing division three sessions, and the refining two sessions, in addition to a joint session of the divisions of Refining and Marketing that will be devoted to automobile operation.

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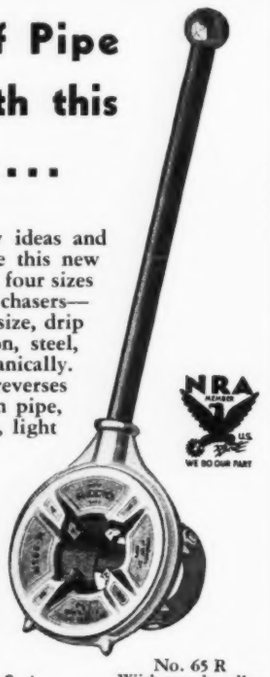

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ON THE BEACH

Lufkin Company Promotes Walter Trout

Walter W. Trout, son of W. C. Trout, president of the Lufkin Foundry & Machine Company, and for seven years manager of the company's Tulsa office, has been transferred to Lufkin, Texas, to become assistant to the president. While

in the Mid-Continent area Walter Trout made an enviable sales record and his promotion to the general offices of the company is a deserved one. D. A. Reid will succeed Mr. Trout in Tulsa and will maintain offices in the Philtower building.

Crescent Field Now Served by Electric Line

With the construction of a high voltage transmission line through the heart of the newly opened Crescent field, Oklahoma Gas and Electric Company is continuing to follow out its policy of pioneering the use of electric power in the oil fields of its state.

Another recent development of this company was the completion of a high-line through the Lucien field, a new pool located southwest of Perry, Oklahoma.

The new lines will provide oil operators in the Crescent and Lucien fields with an ample supply of electric power to take care of the present and future needs for pipe line stations, water stations, gas-lift stations, drilling operations and producing operations.

The advantage of having unlimited electric power available in flush or new fields is that it makes it possible for operating oil companies to make instant decisions and immediate installations of prime mover equipment for all classes of mechanical equipment application that they may desire.

Although it has required large investments, Oklahoma Gas and Electric Company has always shown its eagerness to be of assistance to oil producing companies, oil pipe line companies, and oil refining companies by supplying dependable power for all types of mechanical applications. It has consistently aided in the development of newly opened fields.

The power rate schedules in the Crescent and Lucien fields are the standard schedules that are offered for all fields throughout the state.

Bowen Air Lines Celebrate Third Anniversary

October 1 marked a red letter day in the annals of the Bowen Air Lines when the personnel of the organization celebrated the third anniversary of their operation. During this period of time more than 3,000,000 miles have been flown and more than 35,000 passengers have been carried, according to an announcement by Temple Bowen, president.

With the inauguration of the Bowen Air Lines three years ago the Southwest was given the fastest air schedules ever offered and today the fleet of speedy Lockheed Vegas and Orions still maintain that record. In addition to its speedy scheduled flights several records have been set by Bowen pilots. One of the most outstanding was that of Pilot Dale Francis, who flew the route on a scheduled trip to Tulsa from Dallas in 55 minutes. The regular time for this run is one hour and 45 minutes.

Two very interesting charter trips were made by Bowen Air Lines planes just recently. At the time of the hurricane which left southern Texas devastated, one of the speedy Lockheeds was taken over by Standard Brands, Inc., who loaded 1000 pounds of yeast aboard and rushed it to Corpus Christi, the closest point to the hurricane zone that a landing could be made. From this city the yeast was loaded into trucks and taken to the stricken area in order to prevent a possible bread famine. At the same time, the Associated Press, world-wide news service, chartered another ship and sent a photographer to fly over the entire area. He was flown over 1300 miles in one day and returned to Dallas that same evening, where the photographs were printed and sent to all parts of the United States.

Statement of the Ownership, Management, Etc., of
THE PETROLEUM ENGINEER
October 1, 1933

(This statement is published in compliance with the Act of August 24, 1912).
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Publisher: The Petroleum Engineer Publishing Co., Dallas, Texas.
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Editor: J. L. Dwyer, Dallas, Texas.

Stockholders holding 1 per cent or more of total amount of stock: Warren L. Baker, C. R. Barrett, W. T. Bryan, J. L. Dwyer, W. L. Love, Clarence Morris, K. C. Sclater, F. R. Staley, of Dallas, Texas; T. J. Crowley and Mrs. J. H. Dameron, of Tulsa, Oklahoma.

Known bondholders, mortgagees and other security holders holding 1 per cent or more of the total amount of bonds, mortgages or other securities: Johnston Printing and Advertising Co., Olmsted-Kirk Co., A. Zeese Engraving Co., Jaggars-Chiles-Stovall, Inc., Tower Corporation, F. H. Penn, Texas Power & Light Co., Dallas Clearing House Association, Dallas Gas Co., E. R. Brown, Dallas Power & Light Co., Southwestern Bell Telephone Co., F. R. Schneider, Trustee, F. V. Faulkner, A. Harris & Co., Gulf Insurance Co., Higginbotham-Bailey-Logan Co., Adolphus Hotel, The Schoellkopf Co., Industrial Dallas, Inc., Von Hoffman Press.

W. T. BRYAN, Secretary-Treasurer.

Sworn to and subscribed before me this 29th day of September, 1933.
ELLA DALY, Notary Public.
(My commission expires June, 1935).

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Cracking

◀ Article III. Typical Design Calculation

By W. L. NELSON
Professor of Petroleum Refining,
University of Tulsa

THE design of cracking equipment is an involved computation and the following calculations have been simplified in many ways. The standard pieces of equipment such as coolers, exchangers, fractionating towers, separators, accumulators, etc., will not be discussed. The general flow diagram is indicated in Fig. 1. While the flow diagrams of most cracking plants do not appear as shown in Fig. 1, an inspection of the processing used in almost all modern or newly remodeled plants, will show that they are essentially the same as in Fig. 1. Only a clean distilled stock is subjected to cracking conditions and the hot cracked oil is rapidly cooled by the fresh charge stock at point "F" in the flow diagram.

Basis of Design. Capacity, 2000 bbl. per day of a mixed base reduced crude charging stock.

An analysis[1] of the charging stock is shown in Fig. 2. The ultimate yields that may be expected can be determined by the operation of a replica cracking plant in the laboratory, or by an inspection of cracking plant data. Such data have been correlated[2] in Article II of this series. The yields when cracking a fuel oil to 400 deg. fahr. endpoint gasoline and a residue of cracked fuel oil or tar are as follows:

Per cent gasoline = 25 + 1.5 (A.P.I. of stock — A.P.I. of tar).

Per cent unaccounted for loss=0.45 (A.P.I. of stock— A.P.I. of tar).

If the tar is allowed to stand for a long soaking time (incipient cracking) before it leaves the evaporator "A," a tar of 8 A.P.I., having a suitable viscosity, can be produced. The residue from the rerunning of the pressure distillate will also be blended with the tar. The difference in the A.P.I. of the stock and of the tar will be 26 — 8, or 18, making the approximate ultimate yield:

400 endpoint gasoline	52.0%
Unaccounted for loss and gas	8.1%
Total tar by difference	39.9%

The approximate yields of pressure distillate and unblended tar are:

430 endpoint pressure distillate	56.0%
Unaccounted for loss and gas	8.0%
Unblended tar	36.0%

The finished yields of 400 gasoline and marketable tar will be a little less than 52 per cent and 39.9 per cent because of the treating and rerunning losses. Endpoint gasoline has been produced directly from the cracking plant in a few cases, but the rerunning of a pressure distillate is the common practice.

Material Balances. The quantities of material handled at various points is greatly dependent upon the recycle ratio or the allowable crack per pass. The maximum yield[3] per pass at about 900 deg. fahr. is about 35 per cent. At this yield active polymerization takes place and coke will be produced in the tubes. In order to avoid coking, the crack per pass should not exceed about 20 per cent.[3] Using 20 per cent, the amount of material that must pass through the cracking still to produce a total of 56 per cent of pressure distillate must be 56 divided by 20 or 2.8 times as much as the original charge stock. In barrels the furnace charge will be 2.8 times 2000 or 5600 bbl. per day.

In Fig. 1 it will be noted that all materials except the tar, leave the evaporator "A" as vapors and pass into the fractionator "B." The fixed gas and pressure distillate pass through the fractionator as vapors, but the gas oil and the recycle collect as a liquid in the base of the tower and constitute the charge stock for the furnace "C." The quantity of gas oil that is topped from the reduced crude is dependent on the temperature in the evaporator and the character of the reduced crude. Experience has shown that coke will be deposited in the evaporator if the temperature

[1]Nelson, *Petroleum Engineer*, April, 1931.
[2]Nelson, *Petroleum Engineer*, August, 1933.

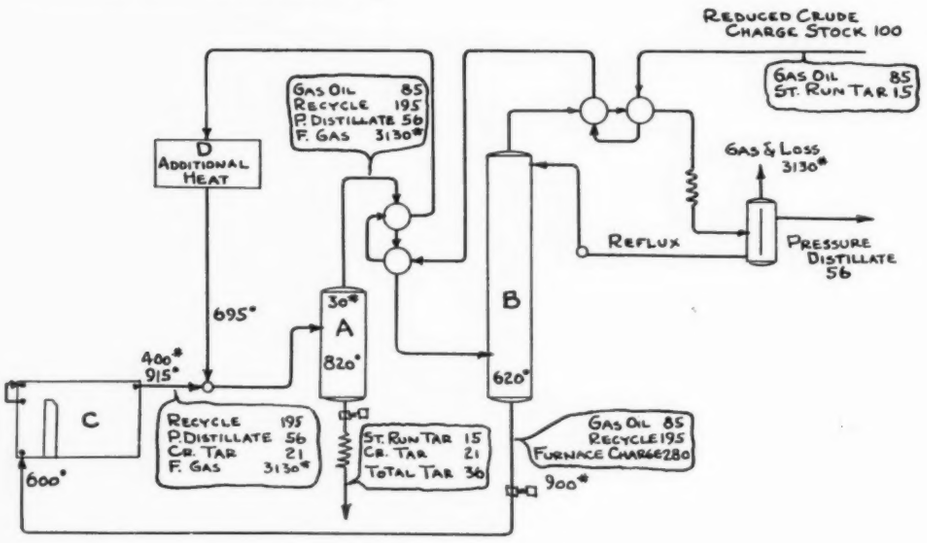

Fig. 1—Flow Diagram

[3]Nelson, *Petroleum Engineer*, August, 1933, Table III and Fig. 1.

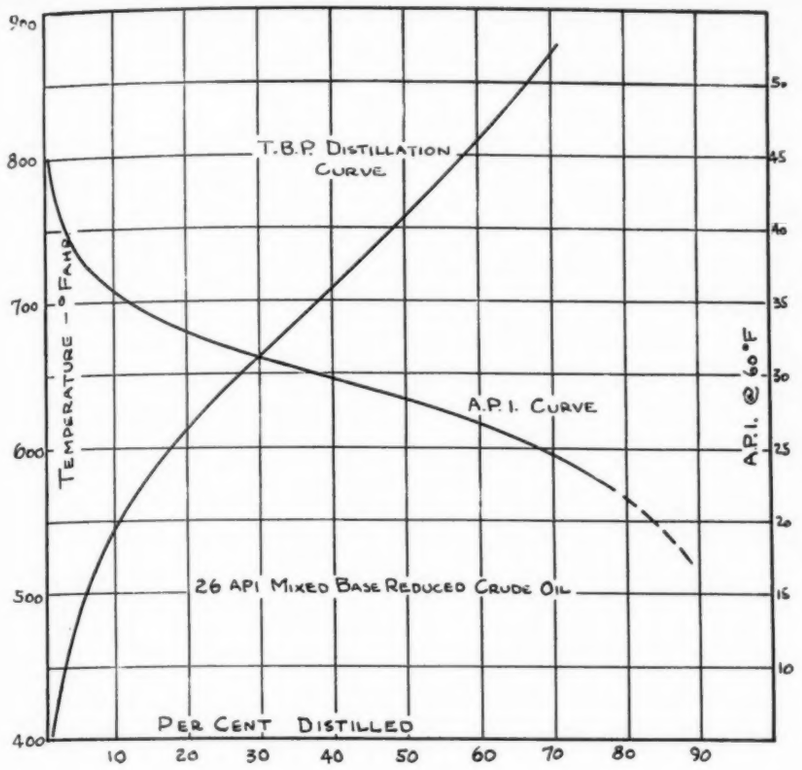

Fig. 2—Analysis of charging stock

exceeds about 820 deg. fahrenheit. From this particular reduced crude about 85 per cent of gas oil will be vaporized by flashing at 820 deg. fahr. and soaking for 20 or 30 minutes in the evaporator. The amount of vaporization can be estimated by drawing the flash vaporization curve[4] and applying a small correction for the effect of the fixed gas and the effect of the soaking.

The composition of the charge stock to the still is shown in Table I.

The A.P.I. of the recycle must be assumed from a knowledge of cracking plant operation. In general the A.P.I. of a pure recycle stock is a little more than half the A.P.I. of the uncracked gas oil unless coking is practiced. The recycle by coking has even a lower A.P.I.

The composition of the tar is shown in Table II.

The pounds and volume of cracked tar were obtained by difference and from these two, the density and A.P.I. were computed.

The materials leaving the cracking still are shown in Table III. Since there is an increase in volume during cracking,[5] the gas is obtained by means of a weight balance of the liquid materials entering and leaving the still.

The percentages, based on R. crude as given in Tables I, II, and III are shown on Fig. 1 and will help in clarifying the route taken by the several materials.

Pressure, Temperature and Time. The pressure at the outlet of the still should be high enough to produce an almost pure liquid phase, or at least high enough to cause the density of such vapor as may be produced, to be nearly the same as the density of the liquid. In this way a separation of the two phases may be avoided. Originally a pressure of 1000 lb. per sq. in. was thought to be necessary, but recently pressures of 350-400 lb. have been successfully used. When using a cold (computed at 60 deg. fahr.) velocity of six ft. per sec. the pressure drop[6] should not be more than 500 lb. per sq. in. (with clean tubes) and the pressure at the charge pump will be about 900 lb. per sq. inch. As coke accumulates in the tubes the pressure may rise to 1200 lb. per sq. inch.

Under the above conditions the cracking temperature will be between 900 deg. and 930 deg. fahrenheit. Using 915 deg. fahr. as the average cracking temperature, the time in the cracking zone may be computed. At 900 deg. fahr. a yield of 20 per cent is obtained from gas oil in about 110 seconds.[7] Recycle stock cracks about half as easily, or requires double the time or, 220 seconds at 900 deg. fahrenheit. In this plant a mixture of 2.3 parts of recycle to one part of gas oil is to be cracked. For this mixture a time of about 190 seconds is required. Referring to Reference 7, Fig. 2, the yields are:

From fresh gas oil, $1 \times 30.6 = 30.6$
From recycle - $2.3 \times 15.3 = 35.2$

65.8

65.8 divided by $3.3 = 20\%$

The time required at 915 deg. fahr. for the furnace charge may be computed as follows:[8]

$$V_2 = V_1/2^{(T_1 - T_2)/tr}$$

$V_1 = 190$ at 900 deg. fahrenheit
$T_1 = 900$ deg. fahrenheit
$T_2 = 815$ deg. fahrenheit
$tr = 23$

The time at 915 deg. fahr. is 121.0 seconds.

The Cracking Zone. The diameter of the tubes may be determined by using the allowable cold velocity of six ft. per second. The volume of oil at 60 deg. fahr. is about 0.365

TABLE I

	bbl./day	% R. Crude	A.P.I.	lb./gal.	gal./hr.	lb./hr.
Furnace charge...	5600	280	21.0	7.73	9800	75700
Gas oil.....	1700	85	29.3	7.33	2970	21800
Recycle (diff.)....	3900	195	17.9	7.89	6830	53900

TABLE II

	% R. Crude	bbl./day	A.P.I.	lb./gal.	gal./hr.	lb. hr.
Total tar.....	36	720	8	8.45	1260	10640
St. run tar.....	15	300	13.5*	8.13	525	4270
Cracked tar.....	21	420	4.5	8.66	735	6370

*Approximation from Fig. 1.

TABLE III

	% R. Crude	bbl./day	A.P.I.	lb./gal.	gal./hr.	lb./hr.
Materials in—Furnace charge....	280	5600	21.0	7.73	9800	75700
Materials out—						
Recycle.....	195	3900	17.9	7.89	6830	53900
Pressure distillate.....	56	1120	56.0*	6.28	1960	12300
Cracked tar....	21	420	4.5	8.66	735	6370
	272	5440	.....	.....	9525	72570
Fixed gas (diff.)	29.8†	.....	.....	3.0*	1040	3130
	301.8	.....	.....	.....	10565	75700

*Estimated.
†Useful only for estimating volume in cracking zone.

[4]Nelson and Souders, *Petroleum Engineer*, October, 1931.
[5]Nelson, *Petroleum Engineer*, August, 1933, p. 27.
[6]This pressure drop can be computed by the common methods.
[7]Nelson, *Petroleum Engineer*, July, 1933. Fig. 2.
[8]Nelson, *Petroleum Engineer*, July, 1933, p. 32.

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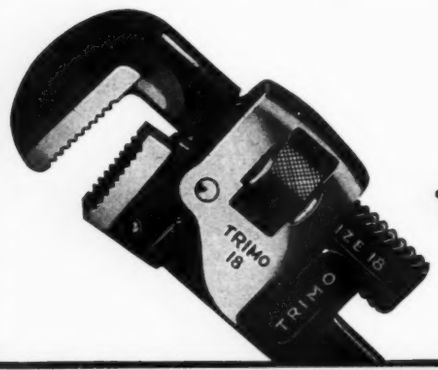

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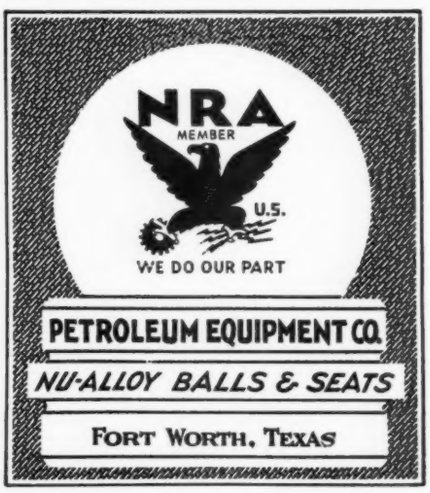

cu. ft. per second. This requires a tube area of 8.8 sq. in. or an internal diameter of about 3⅜ inch. A 3½-in. I.D. tube would be used corresponding to a cold velocity of 5.5 ft. per second. Since the hot oil would travel at about five times[9] the cold velocity, or at about 28 ft. per sec., the length of effective tubing required would be 28 times 121.0, or 3390 ft. Using 4½-in. O.D. tubing, the projected area of the cracking zone would be 1270 sq. feet.

The main heat required in the cracking zone is for decomposition, but some heat is required for simple heating. The heat of decomposition is approximately 660 B.t.u. per lb. of gasoline,[10] and the total heat for decomposition is 12300 times 660, or 8,130,000 B.t.u. per hour. The oil may be assumed to rise 50 deg. fahr. in the cracking zone so that this heat requirement is 50 times 75,700 times about 0.93, or 3,520,000 B.t.u. The total heat in the cracking zone is 11,650,000 B.t.u. and the absorption rate is 11,650,000 divided by 1270, or 9,160 B.t.u. per sq. ft. of projected area. To allow for a small amount of vaporization if some should occur, the radiant section will be designed for about 11,000 B.t.u. per sq. ft. of projected area. The time in the cracking zone can be easily adjusted during plant operations by changing the still outlet temperature slightly. A change in outlet temperature of plus or minus five degrees from the design temperature of 915 deg. fahr. should take care of any inaccuracies in the cracking zone design.

The cracking zone is often placed in the convection section rather than in the radiant section. In such a design a part of the convection section is selected in which the rate of heat absorption is the same as the above. The use of the convection section for cracking has the advantage of keeping the tube wall temperatures lower as the tube collects coke, but at the same time it is difficult to locate the exact position for the cracking zone in the convection section and a recirculation still is almost necessary.

Heat Balances. The temperature at which the reduced crude must enter the evaporator is an important temperature. This may be determined by a heat balance of the materials entering and leaving the evaporator.

Heat available:		
Sensible heat in Recycle	53,900 (915—820) 0.785[11] =	4,020,000
Sensible heat in P.D.	12,300 (915—820) 0.775[11] =	905,000
Sensible heat in Cr. Tar	6,370 (915—820) 0.8 =	485,000
Sensible heat in F. Gas	3,130 (915—820) 0.84[11] =	250,000
	Total B.t.u. =	5,660,000
Heat required:		
Lb. of R. crude equals 26,200 lb.		
Latent heat of Recycle	53,900 × 35 =	1,890,000
Latent heat of Gas Oil	21,800 × 45 =	980,000
	B.t.u.	2,870,000

[9]Nelson, *Petroleum Engineer*, August, 1933, p. 28.
[10]Nelson, *Petroleum Engineer*, July, 1933, p. 33.
[11]Specific heat of vapors.

Heat available to raise temperature of reduced crude equals 2,790,000 B.t.u.

This heat will raise the R. crude from 695 to 820 deg. fahrenheit. If sufficient heat is not available to heat the reduced crude to 695 deg. by heat exchange, additional heat must be added. (Note "D"). This heat may be supplied in another pipestill, in a shell still, by an elaborate heat exchange system or by building a larger cracking pipestill and using a part of it to heat the R. crude. The latter arrangement is not altogether satisfactory because the heat input in the two separate coils cannot be easily regulated. The heat exchanger method is not entirely satisfactory because high temperature vapor-heat exchangers give trouble.

Heat Balance of Pipestill. When burning wet cracked gas with 35 per cent of excess air (CO_2 9.2 per cent) and absorbing heat at the rate of 11,000 B.t.u. the per cent[12] of the net heat that is absorbed in the radiant section is about 60.

The furnace charge arrives at the pipestill at about 600 deg. fahr., so that the flue gas temperature as it leaves the still must be at least 800 deg. fahrenheit. This gives a stack loss of about 22 per cent.

Radiant absorption - - - - - - -	60%
Radiant loss - - - - - - - - -	4
Stack loss - - - - - - - - - -	22
Convection loss - - - - - - - -	1
Convection absorption (diff.) - - -	13

The quantity of heat required in the still cannot be computed directly because physical data for oil at such high temperatures and pressures are not available. However, a close approximation can be had by computing the "total heat" required to heat the charge to 915 deg. fahr. at atmospheric pressure. In this manner the charge is heated to about 700 deg. fahr. as a liquid, vaporized at this temperature and the vapors heated to 915 deg. fahrenheit. Although probably only a small amount of vaporization occurs at 915 deg. fahr. in the plant, the latent heat is included in the above because at the critical temperature, about 900 deg. fahr., for the lighter constituents of the charge, the heat of the liquid is the same as the heat of the vapor.

Sensible heat to 700 deg.	75,700 (700—600) 0.76 =	5,750,000
Latent heat at 700 deg.	75,700 × 52 =	3,940,000
Sensible heat of vapors	75,700 (915—700) 0.71 =	11,550,000
Heat of decomposition	12,300 ×660 =	8,130,000
Heat to be absorbed	=	29,370,000
Heat developed (eff. 73%)	=	40,200,000

At a net heating value of 1700 B.t.u. per cu. ft. for wet cracked gas, 23,000 cu. ft. of gas per hour will be required.

The amount of gas produced in this plant is 3130 lb. per hr., or approximately 37,000 cu. feet.

[12]Nelson, *Petroleum Engineer*, April, 1933. Fig. 1.
[13]Nelson, *Petroleum Engineer*, February, 1933. Fig. 2.

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